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UNITED STATES DISTRICT COURT
DISTRICT OF OREGON
MEDFORD DIVISION

| | |
|---|---|
| KLAMATH-SISKIYOU WILDLANDS CENTER, OREGON WILD, and CASCADIA WILDLANDS,<br>*Plaintiffs,*<br>vs.<br>UNITED STATES FISH AND WILDLIFE SERVICE,<br>*Defendant*,<br>and<br>BOISE CASCADE WOOD PRODUCTS, L.L.C., and TIMBER PRODUCTS COMPANY,<br>*Defendant-Intervenors*. | Civ. Case No. 21-cv-00058-CL<br><br>DECLARATION OF SUSAN JANE M. BROWN |

I, Susan Jane M. Brown, declare as follows:

1. I am one of the attorneys of record for plaintiffs Klamath-Siskiyou Wildlands Center, Oregon Wild, and Cascadia Wildlands in the above captioned matter. I am filing this declaration

to authenticate documents cited in Plaintiffs' Memorandum in Support of Motion for Temporary Restraining Order/Preliminary Injunction.

2. Federal defendants have not yet filed an administrative record in this case.

3. Attached hereto as **Exhibit A** is a true and correct copy of the United States Fish and Wildlife Service's Biological Opinion on *Medford District of the Bureau of Land Management's FY20 Batch of Projects that May Affect the Northern Spotted Owl and its designated Critical Habitat (Reference Number 01EOFW00-2020-F-0508)*. This document is cited in Plaintiffs' Motion and Memorandum in Support of Motion for Temporary Restraining Order/Preliminary Injunction as "**the BiOp**."

4. Attached hereto as **Exhibit B** is a true and correct copy of Memorandum from State Supervisor, Oregon Fish and Wildlife Office, to Acting Assistant Regional Director, Ecological Services, Interior Regions 9/12, Portland, Oregon (Jan. 15, 2021); *see also*, *Endangered and Threatened Wildlife and Plants; Revised Designation of Critical Habitat for the Northern Spotted Owl; Delay of Effective Date*, 86 Fed. Reg. 22,876 (April 30, 2021) (referenced as "FWS 2021b"), also available at Regulations.gov, Fish and Wildlife Service, *Endangered and Threatened Wildlife and Plants; Revised Designation of Critical Habitat for the Northern Spotted Owl Rulemaking Docket,* (March 1, 2021), https://www.regulations.gov/document/FWS-R1-ES-2020-0050-1784 ("Browse & Comment on Documents;" "Henson Jan 7 21 memo response to Director nso ch"). This document is cited in Plaintiffs' Motion and Memorandum in Support of Motion for Temporary Restraining Order/Preliminary Injunction as "**FWS 2021b**."

5. Attached hereto as **Exhibit C** is a true and correct copy of the 2011 Northern Spotted Owl Recovery Plan. This document is cited in Plaintiffs' Motion and Memorandum in Support of Motion for Temporary Restraining Order/Preliminary Injunction as "**Recovery Plan**."

6. Attached hereto as **Exhibit D** is a true and correct copy of Franklin, A.B. 1992. *Population regulation in northern spotted owls: theoretical implications for management*. Pages 815-827 in D. R. McCullough and R. H. Barrett (eds.)., Wildlife 2001: Populations. Elsevier Applied Sciences, London, England. This document is cited in Plaintiffs' Motion and Memorandum in Support of Motion for Temporary Restraining Order/Preliminary Injunction as "**Franklin et al. 1992**."

7. Attached hereto as **Exhibit E** is a true and correct copy of Forsman, E.D., Anthony, R. G., Reid, J. A., Loschl, P. J., Sovern, S. G., Taylor, M., Biswell, B. L., Ellingson, A., Meslow, E. C., Miller, G. S., Swindle, K. A., Thrailkill, J. A., Wagner, F. F., and D. E. Seaman. 2002. *Natal and breeding dispersal of northern spotted owls. Wildlife Monographs*, No. 149. 35 pp. This document is cited in Plaintiffs' Motion and Memorandum in Support of Motion for Temporary Restraining Order/Preliminary Injunction as "**Forsman et al. 2002**."

8. Attached hereto as **Exhibit F** is a true and correct copy of Wiens, J.D., Dugger, K.M., Lesmeister, D.B., Dilione, K.E., and Simon, D.C., 2020, *Effects of barred owl (Strix varia) removal on population demography of northern spotted owls (Strix occidentalis caurina) in Washington and Oregon—2019 annual report*: U.S. Geological Survey Open-File Report 2020–1089, 19 p., https://doi.org/10.3133/ofr20201089. This document is cited in Plaintiffs' Motion and Memorandum in Support of Motion for Temporary Restraining Order/Preliminary Injunction as "**Wiens et al. 2020**."

9. Attached hereto as **Exhibit G** is a true and correct copy of an excerpt of Reid, J.A.; Forsman, E.D.; Lint, J.B. 1992. *Demography of spotted owls in west central Oregon*. Proceedings of the 62nd annual meeting of the Cooper Ornithological Society symposium; 1992 June 22-28; Seattle, WA. This document is cited in Plaintiffs' Motion and Memorandum in

Support of Motion for Temporary Restraining Order/Preliminary Injunction as "**Reid et al. 1992**."

10. Attached hereto as **Exhibit H** is a true and correct copy of Information Bulletin No. OR-2017-063, *Timber Sale Planning Approaches to Avoid Take of Northern Spotted Owls Under the 2016 Resource Management Plans* (July 21, 2017). This document is cited in Plaintiffs' Motion and Memorandum in Support of Motion for Temporary Restraining Order/Preliminary Injunction as "**Information Bulletin**."

I declare under penalty of perjury that the foregoing is true and correct.

Dated this 10th day of May, 2021.

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*Attorney for Plaintiffs*

# EXHIBIT A

# United States Department of the Interior

FISH AND WILDLIFE SERVICE

Roseburg Field Office
777 NW Garden Valley Blvd
Roseburg, Oregon 97471
Phone: (541) 957-3474 FAX: (541) 440-4948

In Reply Refer To: # 01EOFW00-2020-F-0508
Filename: Medford District BLM FY20 Batch of Projects
Tails #: 01EOFW00-2020-F-0508
TS#: 20-515

July 24, 2020

To: District Manager, Medford District
Bureau of Land Management
Medford, Oregon

JAMES THRAILKILL Digitally signed by JAMES THRAILKILL Date: 2020.07.24 16:37:31 -07'00'

From: Field Supervisor, Roseburg Fish and Wildlife Office
Roseburg, Oregon

Subject: Formal Consultation on the Medford District of the Bureau of Land Management's FY20 Batch of Projects that May Affect the Northern Spotted Owl and its designated Critical Habitat (Reference Number 01EOFW00-2020-F-0508).

This memorandum transmits the Fish and Wildlife Service's (Service) Biological Opinion (Opinion) addressing the Medford District (District) Bureau of Land Management's (BLM) Fiscal Year 2020 (FY20) Batch of Projects for forest management activities across the District. At issue are the effects of the proposed action (Proposed Action or Project) which may affect the northern spotted owl (*Strix occidentalis caurina*) (spotted owl) and spotted owl designated critical habitat. This consultation was prepared in accordance with the requirements of section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.).

The enclosed Opinion is based on information provided in the District's Assessment (Assessment) (USDI BLM 2020), received by the Service via email on May 21, 2020, as well as other supporting information cited herein. A complete decision record for this consultation is on file at the Service's Roseburg Field Office. The analysis and findings presented herein regarding the effects of the Project on the spotted owl rely on the best available information and the situational context as discussed herein.

The proposed action addressed in the Opinion includes the District's Bear Grub and Round Oak forest management projects. The primary objectives of the FY20 Batch of Projects are to: (1) contribute to the attainment of the declared allowable sale quantity (ASQ) of harvestable timber for the District consistent with the BLM's revised Resource Management Plan (USDI BLM 2016a); (2) reduce forest stand competition; and (3) promote forest resiliency. The District proposes to achieve these objectives by regeneration harvest, commercial thinning, and selection harvest prescriptions along with fuels reduction activities (e.g., mechanical thinning, pruning, burning).

Approximately 8,142 acres of forest-related treatments are proposed resulting in impacts to approximately 11 percent (3,527 acres) of the 31,476 acres of available spotted owl nesting, roosting, and foraging (NRF) habitat within the action areas. Approximately 24 percent (1,945) of treatment acres within the action area occur in the District's Harvest Land Base (HLB) Land-Use allocation (LUA), which is the primary LUA for meeting the ASQ. Approximately 94 percent of NRF proposed for removal is within the HLB. This includes the removal of up to 256 acres of structurally complex forest in the HLB (Assessment, p. 52). Of the total 8,142 acres approximately 26 percent (2,131 acres) of treatment acres occur in capable or non-habitat.

The late-successional reserve LUA is the focal point for spotted owl recovery under the BLM's revised RMP. The only removal of NRF habitat in the LSR LUA consists of low relative habitat suitability (RHS) foraging habitat, not suitable for nesting, consistent with the RMP (USDI BLM Southwest Oregon Resource Management Plan Record of Decision 2016a pp. 71 and 72). Downgrading of up to 53 acres (53 acres in Bear Grub and 0 acres in Round Oak) NRF is proposed in the LSR LUA to achieve forest resiliency objectives that are also consistent with the RMP (p.74).

According to the District, effects to spotted owl habitat caused by the proposed action are likely to be reduced at the time of the NEPA Decision Record because it is anticipated that a certain amount of spotted owl habitat acres will be deferred from harvest for various reasons, including economics or logging feasibility issues, that result in fewer acres being offered for sale. Annual consultation monitoring reports will reflect the actual affected acres for this Project and will be used to adjust the habitat baseline, as appropriate. Based on past implementation experience by the District, the proposed action would likely be implemented over several years resulting in relative incremental impacts to spotted owls and its habitat (Assessment, pp. 1 and 37).

The Service, in August 2016, issued a non-jeopardy and non-adverse modification biological opinion (Opinion) (USDI FWS 2016) on the BLM's revised RMP (USDI BLM 2016a) relative to the northern spotted owl and spotted owl critical habitat. In that Opinion, the conservation needs of the spotted owl (USDI FWS 2016, pp. 486-490) were analyzed by the Service in relation to the Plan level RMP. The Service found the RMP to be consistent with the recovery needs of the spotted owl by providing for a well distributed network of large reserves with adequate opportunities for spotted owl dispersal, and by supporting a barred owl management program if, after compliance with NEPA, MBTA and other applicable requirements, the Service decides such a program would be effective and feasible. In the interim, BLM has committed to developing land management actions in accordance with the RMP that avoid incidental take of spotted owls from timber harvest until a barred owl management program is implemented (USDI

BLM 2016a, p. 30, USDI FWS 2016, p. 4). Finally, the Opinion concluded that land management activities developed in accordance with the RMP should be compatible with the proper function of the spotted owl critical habitat network to serve its intended conservation role (USDI FWS 2016, pp. 702-703).

The RMP and Opinion at the programmatic scale anticipated consultation on individual projects, such as the FY20 Batch of Projects considered herein, to determine site-specific impacts on the spotted owl and its critical habitat (USDI BLM 2016a, pp. 30-31, USDI FWS 2016, p. 5). One of the purposes of site-specific project analysis is to determine if the effects of these projects would result in impacts to spotted owls and critical habitat in a manner or to an extent not consistent with the analysis and conclusions of the 2016 RMP/ROD and the Plan-level Opinion. Under those circumstances, reinitiation of formal consultation on the RMP would be warranted.

In the enclosed Opinion, the Service concludes that the District's implementation of the FY20 batch of forest management projects, including implementation of measures to avoid take of spotted owls, is not likely to jeopardize the continued existence of the spotted owl or to destroy or adversely modify critical habitat because the proposed Project will not appreciably reduce the likelihood of spotted owl survival or recovery. Further, project impacts, taken together with cumulative effects, are not expected to rise to a level that would affect or disrupt the biology of breeding spotted owls at a territory scale or disrupt the ability of spotted owls to disperse at a landscape scale. The proposed action is consistent with the management direction and strategy contained in the RMP to maintain or enhance the function of large blocks of habitat to support successfully reproducing spotted owls and to facilitate spotted owl movement between those blocks.

In addition, the proposed action incorporates discretionary recommendations set forth in the Northern Spotted Owl Recovery Plan (USDI FWS 2011) that when implemented are likely to contribute to the conservation needs of the spotted owl. These actions are consistent with Recovery Actions 6, 10, 29 and 32 of the recovery plan.

The Assessment includes a finding that it may take several years to fully complete the proposed action. This consultation remains valid for the term of the action as discussed in these documents, provided the annual monitoring and reporting described as part of the proposed action are implemented. In accordance with the implementing regulations for section 7 at 50 CFR 402.16, re-initiation of consultation on the proposed action is required where discretionary Federal agency involvement or control over the actions has been maintained (or is authorized by law) and if: (1) the amount or extent of exempted incidental take is exceeded; (2) new information reveals effects of the agencies' action that may affect listed species or critical habitat in a manner or to an extent not considered in the consultation; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the consultation or (4) a new species is listed or critical habitat designated that may be affected by one or both of these actions. When consultation is reinitiated, the provisions of section 7(d) of the ESA apply.

If you have any questions regarding the enclosed Opinion, please contact Michael Asch of the Service's Roseburg Field Office at 541-957-3469.

cc: Robin Snider, District Biologist, Medford District BLM, Medford, Oregon. (e)
Dave Clayton, Forest Biologist, Rogue River-Siskiyou National Forest, Medford, Oregon. (e)

# Biological Opinion
# Addressing
# Medford District Bureau of Land Management's
# FY20 Batch of Projects
# on the Northern Spotted Owl

(FWS Reference Number 01EOFW00-2020-F-0508)

U.S. Department of the Interior
U.S. Fish and Wildlife Service
Roseburg Field Office
July 24, 2020

Signature: JAMES THRAILKILL Digitally signed by JAMES THRAILKILL Date: 2020.07.24 16:38:14 -07'00'

Jim Thrailkill
Field Supervisor

Date Signed: ______________________________

INTERIOR REGION 9
COLUMBIA–PACIFIC NORTHWEST
Idaho, Montana*, Oregon*, Washington
*PARTIAL

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# INTRODUCTION

This document transmits the Fish and Wildlife Service's (Service) Biological Opinion addressing the effects of the Medford District (District) Bureau of Land Management's (BLM) proposed Fiscal Year 2020 (FY20) batch of forest management projects on the northern spotted owl (*Strix occidentalis caurina*) (spotted owl) and spotted owl critical habitat. This consultation was prepared in accordance with the requirements of section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.) (ESA) (Consultation Handbook).

The District's Biological Assessment (Assessment) (USDI BLM 2020) was received via email in the Service's Roseburg Office on May 21, 2020, and is herein incorporated by reference. The Assessment describes and evaluates the potential effects of forest-habitat related projects on 8,142 acres of forested lands. The following two projects are analyzed herein: (1) Bear Grub (4,958 acres); and (2) Round Oak (3,184 acres). Based on multiyear contracts, offering timber sales over two fiscal years NEPA procedures and other factors, the District anticipates the proposed actions will be implemented over several years, therefore impacts to spotted owls will be temporally and spatially distributed (Assessment, p. 1). Further, the effects to habitat as described herein could be reduced at the time of the NEPA Decision Record for these two projects because it is likely that some of the acres proposed for treatment could be deferred for various reasons including economics or logging feasibility issues, resulting in fewer acres offered for sale (Assessment, p. 37). Annual consultation monitoring reports will reflect the actual amount of affected acres for these two projects.

The Bear Grub and Round Oak projects have been designed consistent with the BLM's Southwestern Oregon Resource Management Plan and Record of Decision (SWO RMP/ROD) (USDI BLM 2016a). Timber products produced from these projects will be sold in support of the District's Allowable Sale Quantity (ASQ) declared in the 2016 SWO RMP/ROD (USDI BLM 2016a) (Assessment, p.1).

As adopted and embedded in the BLM RMP, project design for the FY20 Batch of Projects includes implementing discretionary conservation recommendations from the Northern Spotted Owl Recovery Plan (USDI FWS 2011). Specifically, the BLM is implementing, to the extent practicable, recommendations 6, 10, 29 and 32, and these are further described herein.

Per the BLM's ROD (USDI BLM 2016a) and the Service's Opinion (USDI FWS 2016), the BLM will not propose timber harvest activities under the proposed action that are likely to result in the incidental take of spotted owls (USDI BLM 2016a, p. 30, USDI FWS 2016, p. 4). When the spotted owl survey season is completed and the results compiled, the Rogue Basin Level 1 Team (Level 1) which was established per interagency consultation streamlining process (USDI BLM et al. 1999) and consists of the Rogue River-Siskiyou National Forest Biologist, the Medford District BLM Biologist, and a Roseburg Fish and Wildlife Office Biologist, will convene (e.g., in September or October) to review the best available survey and site history information. Based on this evaluation, spotted owl site occupancy will be determined (or could occur prior to the Level 1 meeting depending on the adequacy of the information), and these determinations will inform the District's decisions on potential modifications to the FY20 Batch of Projects that are necessary to avoid incidental take of spotted owls caused by this action (see

Project Design Criteria section). The Bear Grub and Round Oak projects combined, are a relatively large batch of projects proposed by the District since the adoption of the BLM's RMP. The batching of projects for consultation is consistent with the BLM's internal direction (USDI BLM 2017) as well as recent ESA revisions (USDI FWS and USDOC NOAA 2019). This approach facilitates the success of BLM to adaptively manage and implement projects of this scale (see USDI BLM 2017).

The primary objectives for the Bear Grub and Round Oak Projects are to meet non-spotted owl-specific objectives such as timber production and forest health to attain the District's ASQ, while still creating resilient forest stands (Assessment, p.11). In doing so, the Project would remove and downgrade some spotted owl habitat. Overall, 1.2 percent of spotted owl nesting, roosting, foraging habitat, and 0.9 percent of the total Federal lands across the District will be impacted by the FY20 Batch of Projects (Assessment, p. 1). The Projects are located within spotted owl critical habitat (77 Federal Register 233:71876-72068).

As standard practice for Medford BLM, a timber sale is considered 'implemented' on the date the project is sold, acknowledging that harvest of timber sales often occurs several years after the sale date. The project is considered 'completed' when all of the on-the ground components are finished. The implementation date for non-timber sale projects will be the date of the work is conducted, date of the decision record or categorical exclusion date, or the contract or task order date (fuels projects, pre-commercial thinning) (R. Snider pers. comm. July, 19, 2020).

Please note that it may take several years to fully complete the activities included in the proposed action (Assessment, p. 37). On that basis, this consultation is valid for the term of the proposed action as discussed and analyzed herein or until an ESA consultation reinitiation trigger has been reached.

## CONSULTATION HISTORY

The Service issued a Biological Opinion on August 5, 2016 (USDI FWS 2016) addressing the BLM's approval of the Southwestern Oregon Resource Management Plan (USDI BLM 2016a). The Service determined the BLM action was not likely to preclude recovery of 19 potentially affected species, was not likely to jeopardize their continued existence, or destroy or adversely modify designated critical habitats (USDI FWS 2016). Of these species, the northern spotted owl occurs on Medford District BLM-administered lands and is the subject of this consultation.

The Bear Grub and Round Oak projects are considered new projects. The Bear Grub and Round Oak projects were presented at a Level 1 team briefing at the Medford Interagency Office on March 4, 2020. A Level 1 field trip to the Bear Grub Project occurred on March 4, 2020, and a Level 1 field trip to the Round Oak Project occurred on December 5, 2019.

A draft of the FY20 Batch of Projects Biological Assessment for formal consultation was submitted to the Level 1 team for review on April 20, 2020. The Service returned comments to the District on May 04, 2020. Recommendations from the Service and the Level 1 team were incorporated into the preparation of the final Assessment to the extent practicable. The final Assessment was submitted to the Service on May 21, 2020.

The District review a draft biological opinion from July 20-23, 2020. The Service has incorporated the District's comments to the extent practicable.

On July 16, 2020, the District and Service through mutual agreement determined that delivery of a final consultation from the Service to the District would be delayed so as to reconcile a few items.

## DEFINITIONS

The terms and definitions listed below are integral to clearly understanding the proposed action and the analyses in this consultation. Throughout this consultation, acreage values (or percentages) are presented and discussed. These values are approximations based on analysis of aerial photographs and some subsequent field review. These acres and percentages may be adjusted as additional information and further field review refines the approximations. Monitoring of project implementation is expected to detect if the acreage amounts identified herein are likely to be exceeded, and, if so, the BLM shall determine (in coordination with the Service) if reinitiation of section 7 consultation is required prior to exceeding the acreage amounts. As mentioned above, it is likely the proposed amount of Project-affected acres will be reduced due to NEPA considerations and logging system limitations.

### ***Land Use Allocations – 2016 SWO RMP***

There are five land use allocations designated in the 2016 Southwestern Oregon Resource Management Plan (USDI BLM 2016a) that occur in the project area: Congressionally Reserved Lands, District-Designated Reserves, Harvest Land Base, Late-Successional Reserves, and Riparian Reserves.

**Congressionally Reserved Lands** are lands set aside to conserve, protect, and restore the identified outstanding cultural, ecological, and scientific values of National Conservation Lands and other congressionally designated lands. These lands include Designated and Suitable Wild and Scenic Rivers and Designated Wilderness and Wilderness Study Areas.

**District-Designated Reserves (DDR)** is the Federal land in which the primary objective is to maintain the values and resources for which the BLM has reserved these areas from sustained-yield timber production. The DDR contains further sub-allocations to guide management based on site-specific values identified; Lands Managed for their Wilderness Characteristics (DDR-LMWC), Areas of Environmental Concern (ACEC), and Timber Production Capability Class (DDR-TPCC).

**Harvest Land Base (HLB)** has specific objectives for sustained-yield timber production. The HLB contains further sub-allocations to guide forest management based on large-scale forest conditions; Uneven-Aged Timber Area (UTA), Low Intensity Timber Area (LITA), and Moderate Intensity Timber Area (MITA).

**Late-Successional Reserves (LSRs)** are Federal lands primarily dedicated to maintaining and promoting the development of habitat for the northern spotted owl and other late-successional species. The LSR LUA is comprised of two sub-allocations: Dry Forest and Moist Forest.

**Riparian Reserves (RRs)** are Federal lands primarily dedicated to maintaining and restoring riparian functions, maintaining water quality, and contributing toward the conservation and recovery of ESA-listed fish species (USDI BLM 2016a, p. 75). The RR LUA is comprised of two sub-allocations: Dry Forest and Moist.

***Activity Periods for the Northern Spotted Owl***

**Table 1**. Northern Spotted Owl Breeding Periods.

| Entire Breeding Period | Critical Breeding Period |
|---|---|
| March 1-September 30 | March 1-July 15 |

***Northern Spotted Owl Sites***

Northern spotted owl site occupancy is defined as locations with evidence of continued use by spotted owls (including breeding), repeated location of a pair or single birds, presence of young before dispersal, or some other strong indication of continued occupancy. Spotted owls are generally monogamous and primarily mate for life (Gutiérrez et al. 1995, p. 10). They are also known to exhibit high site fidelity. However, owls often switch nest trees and use multiple core areas over time, possibly in response to fluctuations of prey availability, loss of a particular nest tree, or presence of barred owls. Spotted owl sites used in this consultation are based on historic information, recent protocol surveys, incidental observations or a combination thereof. For the purposes of this consultation and its analysis, a spotted owl site is the defined "circle area" representing an approximation of a home range. However, because there are often multiple nest locations (original and alternates) that become the "center point" for home ranges (see below), in some cases these multiple areas are combined to represent one spotted owl pair territory and based on site specific information. For the District's assessment, survey history was used to determine whether the original or alternate nest locations (or both) would be analyzed to represent the territory.

**Home Range Circle** is an approximation of the median home range size used by spotted owls. The Medford District uses the median home range estimated for southwestern Oregon of 2,895 acres or a circle with a radius of 1.2 for the West Cascades Province and 3,400 acres or a circle with a radius of 1.3 miles for the Klamath Province (Thomas et al., 1990; Courtney et al., 2004). The Home Range Circle provides a coarse but useful analogue of the median home range for northern spotted owl (Lehmkuhl and Raphael 1993; Raphael et al., 1996). Although it provides an imprecise estimate of actual home ranges, the home range circle approach has been used to show that stand age/structure, patch size, and configuration within the circle influences the likelihood of occupancy. The provincial home ranges of several owl pairs may overlap.

**Core-Use Area Circle** has a radius that captures the approximate core use area, defined as the area around the nest tree that receives disproportionate use (Bingham and Noon 1997). The Medford District uses a 0.5-mile radius (≈500 acre) circle to approximate the core area. Core areas represent the areas that are defended by territorial owls and generally do not overlap the core areas of other owl pairs (Anthony and Wagner1998; Dugger et al., 2005; Zabel et al., 2003; Bingham and Noon 1997).

**Nest Patch** is the 300-meter radius (70 acres) circle around a known or likely nest site and is included in the core and home range areas. Nest area arrangement and nest patch size have been shown to be an important attribute for site selection by spotted owls (Swindle et al., 1997; Perkins 2000; Miller et al., 1989; Meyer et al., 1998). Models developed by Swindle et al. (1997) and Perkins, (2000) showed that the amount of older forest within the 200- to 300-meter radius (and sometimes greater), is positively associated with likelihood of nesting by spotted owls. The nest patch size also represents key areas used by juveniles prior to dispersal. Miller et al. (1989) found that the extent of forested area used by juvenile owls prior to dispersal averaged approximately 70 acres.

### ***Northern Spotted Owl Habitat***

**Canopy Cover** is considered the area of the ground covered by a vertical projection of the canopy (Jennings et al., 1999). Based on best available information, the Rogue Basin Level 1 Team uses canopy cover to measure canopy levels important to spotted owl habitat function. Canopy is important for spotted owls because it provides dispersal/connectivity, thermal cover, and protection from avian predators (Forsman et al., 1984, Thomas et al., 1990). The Team calculates canopy cover averaged at the scale of the treatment unit (see Treatment Unit definition below), which includes a distribution of overstory trees across the unit.

**Nesting, Roosting, Foraging (NRF) Habitat** for the northern spotted owl consists of forest cover types used by owls for nesting, roosting, and foraging. Generally, this habitat is multistoried, 80 years old or older (depending on stand type and structural condition), has high canopy (generally $\geq$60 percent), and has sufficient snags and down wood to provide opportunities for nesting, roosting, and foraging. Other attributes that may be present include large trees with various deformities (e.g. large cavities, broken tops, mistletoe infestations, and other evidence of decadence), large snags, large fallen trees and other woody debris on the ground, and sufficient open space below the canopy for owls to fly (Thomas et al., 1990). Not all of these habitat components need to be present to qualify as NRF habitat. Sometimes only some of the habitat components are present, or all of them are present, but at lower quantities. Nesting habitat is described above and the basal area ranges from approximately180 to 240 $ft^2$/acre, but is typically greater than 240 $ft^2$/acre.

In southwest Oregon, NRF habitat varies greatly, but is typified by mixed-conifer forest, recurrent fire history, patchy habitat components, and a higher incidence of woodrats. It may consist of somewhat smaller tree sizes. One or more important habitat components, such as dead down wood, snags, dense canopy, multistoried stands, or mid-canopy habitat, might be lacking or even absent in portions of southwest Oregon NRF. NRF habitat also functions as dispersal habitat.

**Foraging (F) Habitat** is a subset of nesting habitat (occasionally referred to as Roosting/Foraging (RF)). Even though the stands might have large trees and high canopy, they are often single storied, lack decadent features, and usually have at least 150 $ft^2$/acre basal area. Currently, the Team uses NRF habitat to represent both NRF and Foraging habitat for baseline tracking purposes. The Medford District classifies NRF and Foraging habitat separately, which also helps inform the effects determinations and planning for all projects.

**Dispersal Habitat** at a minimum consists of stands with adequate tree size and canopy to provide protection from avian predators and at least minimal foraging opportunities. Dispersal habitat may include younger and less diverse forest stands than foraging habitat, such as even-aged, pole-sized stands, but such stands should contain some roosting structures and foraging habitat to allow for temporary resting and feeding for dispersing juveniles (USFWS 1992 and USDI FWS 2012b). Dispersal habitat is generally forest stands with an average stand canopy cover of 40 percent or greater and an average diameter at breast height (DBH) of 11 inches or greater. It provides temporary shelter for owls moving through the area between NRF habitats and some opportunity for owls to find prey; but it does not provide all of the requirements to support an owl throughout its life. NRF habitat can also function as dispersal habitat. However, dispersal (or dispersal-only) will be used throughout this document to refer to habitat that does not meet the criteria to be NRF habitat, but has adequate cover to facilitate movement between blocks of NRF habitat. Dispersal-habitat also consists of landscapes with sufficient dispersal-quality habitat that provides for forest connectivity enabling successful dispersal (Thomas et al. 1990, Lint et al. 2005, Davis et al. 2011).

**Stands** are an aggregation of trees occupying a specific area managed as a discrete operational or management unit. A stand may be composed of trees and groups of trees of a variety of ages, species, and conditions, or it may be relatively uniform. A stand may also contain multiple land use allocations (USDI BLM 2016a, p. 314).

**Dispersal Function** for the spotted owl consists of an assemblage of conifer-dominated forest stands that the owls can use for dispersal movements across the landscape. Dispersal habitat for spotted owls includes nesting-roosting, foraging, and dispersal-only habitat. Dispersal habitat and dispersal-only habitat are not synonymous. The term "dispersal habitat" is generally used when describing and discussing the opportunities (e.g., acres of dispersal habitat) for spotted owls to move across the landscape. The Service has generally recommended using a fifth field or larger landscapes for assessing dispersal habitat conditions because watersheds or provinces offer a more biologically meaningful way to evaluate dispersal function. More recent information (Davis, et al. 2016), suggests that landscapes having at least 40 percent of dispersal habitat conditions (including both older and younger forests) would be sufficient to support spotted owl dispersal across the landscape.

**Capable Habitat** for the northern spotted owl is forestland that is currently not habitat but can become NRF, or dispersal habitat in the future, as trees mature and the canopy closes.

**Non-habitat** does not currently provide habitat for northern spotted owls and will not develop into NRF, or dispersal habitat in the future.

***Northern Spotted Owl Habitat Modifications***

**Treatment Unit (or cutting unit)** is the footprint of where trees are actually being cut. Trees left standing outside the perimeter of where cutting is authorized, are by definition, not in the cutting unit and do not count toward canopy cover or basal area retention levels. The cutting unit includes new roads and landings within and adjacent to the cutting unit because the results of these actions also contribute to canopy cover and basal area retention values. It does not include existing roads outside the cutting units or riparian reserves, unless, thinning in the riparian reserve. Larger treatment units may be subdivided into separate effects determinations based on the extent of the prescriptions and existing habitat conditions. The overall goal of defining the cutting unit this way informs an analysis of habitat function pre and post treatment and effects.

**Modify NRF or Dispersal-Only Habitat** is the treatment defined when an action or activity in NRF or dispersal habitat removes some trees or reduces the availability of other habitat components, but does not change the current function of the habitat because the conditions that would classify the stand as NRF or dispersal-only would remain post-treatment (also known as "maintain function"). The treated stand is expected to still function as NRF habitat because it will continue to provide at least 60 percent canopy cover (treatment unit average), large trees, multistoried canopy, standing and down dead wood, diverse understory adequate to support prey, and may have some mistletoe or other decay. The treated stand will still function as dispersal habitat because it will continue to provide at least 40 percent canopy cover (treatment unit average), flying space, and an average of trees 11 inches DBH or greater. In order to maintain function at treatment unit scale, habitat variables should be distributed within that defined area. For example, the stand or unit would not function as NRF or dispersal-only habitat if all of the canopy retention was concentrated on the side or middle of the unit, leaving large gaps that do not provide spotted owl habitat/function. Depending on the scale and intensity of harvest, the results may have adverse effects to spotted owls.

**Downgrade NRF** alters the condition of spotted owl NRF habitat so the habitat no longer contains the variables associated with nesting, roosting, and foraging. Downgraded units would contain trees > 11 inches in diameter and enough tree cover to support spotted owl dispersal. Downgrade is defined when the canopy cover in a NRF stand is reduced to 40-60 percent (treatment unit average) and basal area and layering are significantly reduce to the point that stands are in such a condition that spotted owl would be unlikely to continue to use that stand for nesting or roosting and may lead to increased predation risk by exposing owl to other raptors. Best available information suggests that downgrading NRF may still provide foraging habitat, albeit on site specific conditions and downgraded NRF continues to provide habitat for dispersal.

**Remove NRF** alters known spotted owl NRF habitat so the habitat no longer functions as nesting, roosting, or foraging habitat. Removal generally reduces canopy cover to less than 40 percent (treatment unit average), alters the structural diversity and dead wood in the stand or otherwise changes the stand so it no longer provides nesting, roosting, or foraging, or even dispersal habitat for owls. The removal of these key habitat features would reduce the roosting, foraging, and dispersal opportunities for owls in the action area, and lead to increased predation risk. These treatment acres would not be expected to provide functioning NR or F habitat for decades post-treatment.

**Remove Dispersal** alters known spotted owl dispersal-only habitat so the habitat no longer functions as dispersal habitat. Removal generally drops canopy cover to less than 40 percent (treatment unit average) and otherwise changes the stand so it no longer provides dispersal habitat for owls. The post-harvest stand would be too open to provide protection from predators.

## DESCRIPTION OF THE PROPOSED ACTION

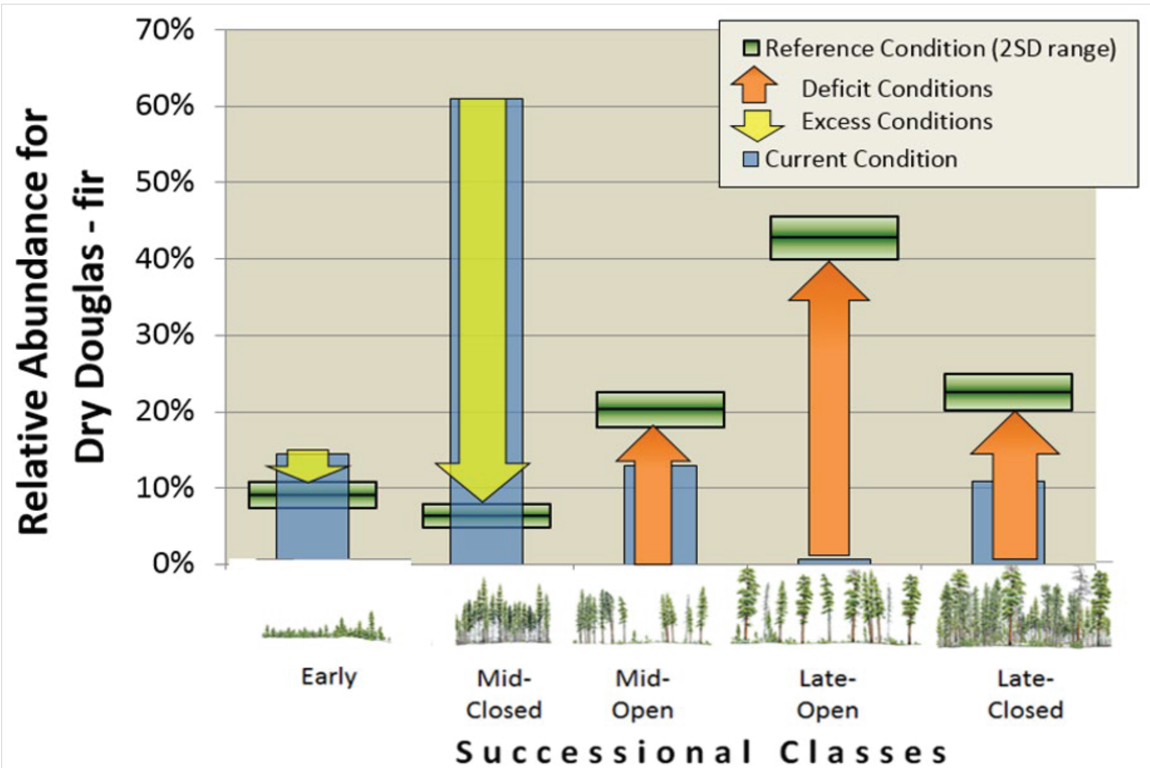
The Assessment (pp. 7–24), along with the Assessment's Appendices A, B and C provide details of the proposed action for the FY20 Batch of Projects. The following represents a summary of the Proposed Action as represented in the Assessment.

### Project Area History and Current Condition

Forest management direction can be informed by past management history and historical range of natural conditions. For example, there is a range of structural stages within a forest area at any given time, which can be analyzed against a historical reference condition to determine if desired structural attributes are present and whether management is needed to address structural composition issues. These classes typically include: (1) Early successional, (2) Mid-development Closed Canopy, (3) Mid-development Open Canopy, (4) Late Development Open Canopy, and (5) Late Development Closed Canopy. The definition of each s-class in terms of species composition, stand structure, and stand age is unique for each biophysical setting (USDI BLM, 2016b, p.1308). However, the approximate class thresholds are as follows: The early successional class includes Establishment vegetation comprised of grass, herbs, shrubs, and tree seedlings to saplings and poles. The mid successional class includes stands with pole (8" DBH) to large (20" DBH) sized conifers, while the late successional class includes stands with large sized (> 20"DBH) conifer. The open category represents overstory canopy cover that is < 40 percent and the closed canopy cover represents overstory canopy cover > 40 percent.

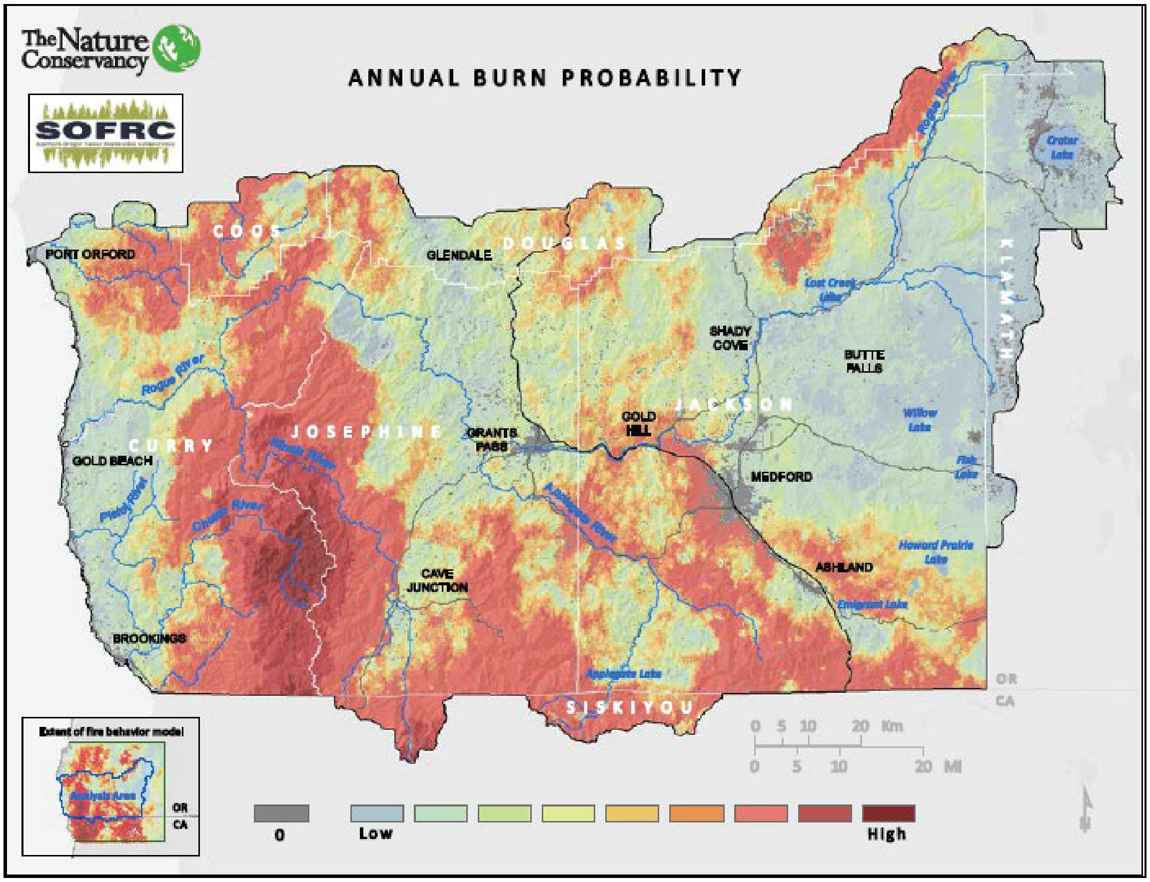
As displayed in Figure 1, overall across the Medford District, there is an abundance of early and mid-closed structural classes; whereas in contrast, mid-open, late-open, and late-closed classes is less represented compared to reference conditions (Assessment, p. 8) with the difference ranging from 5 to 55 percent. Because of these conditions, best available information indicates a high likelihood of high severity fire and potential loss of spotted owl habitat.

**Figure 1. Medford District Structural Class Departure from Natural Range of Variability for Dry Douglas-fir (Assessment, p. 8).**




After missing several fire return cycles, the likelihood of uncharacteristic fire behavior and high severity fire has increased due to the buildup of fuels (Brown et al. 2004, Hessberg et al. 2005, Kauffman 2004, Reinhardt et al. 2008, Ryan et al. 2013). Haugo et al. (2015) categorized the forest restoration needs across Oregon and Washington, and found that not only does southwest Oregon demonstrate the highest need for active forest restoration in the region, but many of the watersheds across the Medford District (lands located primarily in the center portion Figure 2) are among the most in need of active management to promote forest resiliency. Lesmeister et al. (2019b) concluded that older mixed conifer forests are less susceptible to high-severity fire than other successional stages, even under high fire weather conditions, but notes that habitat suitability is reduced or lost when they do burn at moderate and high severity. The 2011 Revised Recovery Plan addresses this concern and recommends conserving older more structurally complex habitat and strategically treating around older forest habitat. The Recovery Plan further recommends active management that includes the strategic placement of projects guided by a landscape context where practicable. Metlen et al. (2017) generated an annual burn probability map for the Rogue Basin (Figure 2) that further illustrates fire risk in southwest Oregon and the need for active management.

**Figure 2. Rogue Basin Annual Burn Probability for the Rogue Basin, Southwest Oregon (Metlen et al. 2017).**




FSim generated annual probability of a 2-ac pixel burning in a fire >35-ac for the 10 million-ac fire behavior modeling area (see inset) centered on the 4.6 million-ac Rogue Basin Project area (Metlen et al. 2017, p. 15).

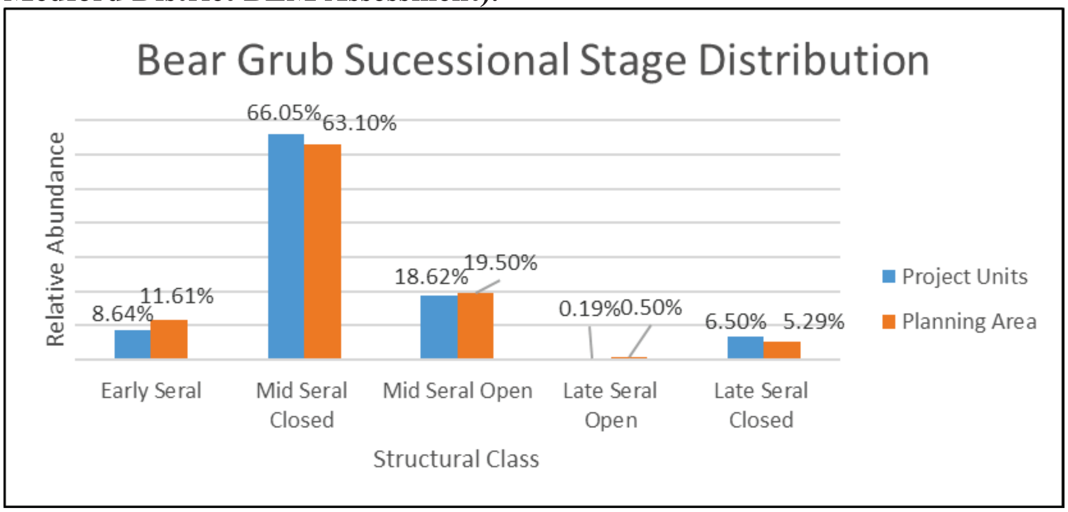
### *Bear Grub Project Area Current Vegetation Conditions*

The Bear Grub Project Area is located just south of the city of Jacksonville and east of the town of Ruch in Jackson County, Oregon. These lands are a mix of BLM-administered, Oregon Department of Forestry, and private, or individual company ownership. The project is within three 5th field watersheds (Middle Applegate, Little Applegate, and Bear Creek watersheds). The current landscape pattern of the vegetation here is a result of highly dissected topography, fires, wind events, timber harvesting, and forest pathogens.

The Bear Grub project area is between 1,700 and 5,500 feet in elevation and lies within the Klamath Mountain Province as described by Franklin and Dyrness (1973). Moisture and temperature gradients differ between forest zones creating a unique pattern of various vegetation types throughout the project area, which are broadly correlated with elevation. Vegetation within this area is summarized according to Plant Associations Groups (PAG) of Southern Oregon (Atzet 1996). Douglas-fir plant associations comprise the majority of forestland in the

Project Area. At the highest elevations on the eastside of the planning area the PSME (Douglas-fir)-ABCO (white fir) and PSME-ABCO/PIPO (ponderosa pine) plant associations are present. When rainfall is abundant, or the aspect is more conducive to cooler temperatures (such as north and east aspects), the plant associations most often found include PSME-PIPO, and PSME-BENE (dwarf Oregon grape). On the drier sites the PSME-RHDI (poison oak) and PSME-RHDI-BEPI (Piper's Oregon grape) plant associations are most prevalent. Pine and white oak series forests are usually found on south and west aspects and the lowest elevations (PIPO-QUKE (California black oak) and PIPO-PSME).

**Figure 3. Current Bear Grub Structural Class Abundance, Medford District BLM (source Medford District BLM Assessment).**




**Successional class definitions on file with the Medford District BLM.*

Overall, for the Bear Grub project, 45 percent of the treatments would promote resiliency as an objective while 55 percent may result in resiliency as a secondary benefit. These outcomes are expected due to the nature of treatments in UTA, which compose 100 percent of the HLB treatments in Bear Grub.

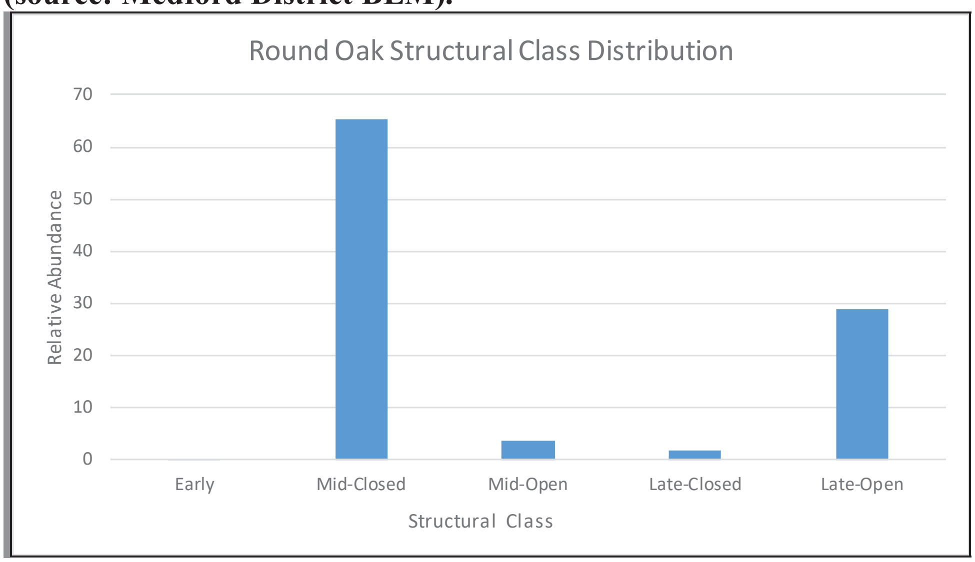
***Round Oak Project Area Current Vegetation Conditions***

The proposed Round Oak project area is roughly split between two fifth field watersheds the South Fork of the Rogue River to the north and Big Butte watershed to the south. The stands proposed for treatment are geographically bound in the north by Round Mountain at an elevation of approximately 5,000 ft and the west flank foothills of Oak Mountain in the southern portion of the project at ~3,000 ft. Aspects represented are moderately variable and have an influence on existing vegetation condition. South and west aspects tend to be the hotter and drier and have xeric forest conditions. Whereas the north and east aspects are cooler and relatively more moist throughout the growing season and in general have a higher carrying capacity for vegetation as compared to south and west slopes.

The Round Oak project is within one distinct ecoregion province: Cascades West (Thompson et al. 2003). Overstory dominate tree species and associated understory vegetation within the project area is summarized according to Plant Associations Groups (PAG) of Southern Oregon

(Atzet 1990). There are four major forested PAGs found in the project area: White fir-Intermediate is the most dominant PAG accounting for approximately one third of the project area (36 percent), White fir – cool (26 percent) and Douglas fir-dry (24 percent) each account for a quarter of the project area. Western Hemlock Intermediate is the fourth most abundant PAG at ~7 percent of the area. Four other Moist and Dry PAGs less than 2 percent each account for the rest of the forested areas. Non forest PAGs account for the remainder of the project area. For the actual proposed treatment units the same four dominate PAGs are represented in the project area are reflected in the units with a slight difference in distribution. White fir – Intermediate is 43 percent, White fir – Cool 34 percent and Douglas fir – Dry at 13 percent of the proposed units. In general low elevation species composition is consists of pine/oak dominance. Mid elevation species composition is reflective of mixed conifer forest type with the following specific species present in order of dominance: Douglas fir, ponderosa pine, incense cedar, sugar pine, white fir, Oak Sp., and madrone. High elevation stands have species composition similar to mixed conifer forest types, but with greater proportions of white fir and Western hemlock. Land ownership patterns, past timber harvest, windstorms, wildfires, and fire exclusion have created the highly variable vegetation existing structural conditions in the Round Oak Project Area (Figure 4). The present-day vegetation pattern across the watershed landscape results from the dynamic processes of natural and human influences over time.

**Figure 4. Current Round Oak Structural Class Abundance, Medford District BLM (source: Medford District BLM).**




***Successional class definitions on file with the Medford District BLM***

Overall, for the Round Oak project, 16 percent (fuels treatments) of the treatments would promote resiliency as an objective while 34 percent may result in resiliency as a secondary benefit. The remaining 50 percent of treatments are within MITA and LITA (ASQ as the primary objective) and are not anticipated to promote resiliency as an outcome.

**Proposed Action Overview**

The District's FY20 Batch of Projects have been designed consistent with the 2016 SWO RMP/ROD (USDI BLM 2016a) to accomplish specific LUA management directions (Table 2). These LUA objectives include: harvest timber to contribute to the attainment of the declared ASQ for the Medford District, reduce tree competition and promote forest resiliency. Timber products produced from these projects are sold in support of the District's ASQ declared in the 2016 SWO RMP/ROD (USDI BLM 2016a). Approximately 70 percent of the harvest is planned for the HLB.

**Table 2. Medford District BLM 2016 SWO RMP/ROD Land Use Allocation for the Bear Grub and Round Oak Projects.**

| Project | 2016 Land Use Allocation[1] Acres | | | | | | |
|---|---|---|---|---|---|---|---|
| | HLB – MITA | HLB – LITA | HLB-UTA | DDR[2] | LSR | RR | Total Acres |
| **Bear Grub** | 0 | 0 | 2,743 | 1,251 | 446 | 518 | **4,958** |
| **Round Oak** | 430 | 1,394 | 1,073 | 120 | 5 | 162 | **3,184** |
| **TOTAL** | **430** | **1,394** | **3,816** | **1,371** | **451** | **680** | **8,142** |

1 - HLB-MITA=Moderate Intensity Timber Area; HLB-LITA = Harvest Land Base-Low Intensity Timber Area; HLB-UTA= Harvest Land Base – Uneven-Aged Timber Area; DDR= District Designated Reserve; LSR = Late Successional Reserve; RR – Riparian Reserve (see definitions); 2 - The DDR acres in the projects include TPCC lands, roads, and water.

**Project Objectives and Development Strategies**

According to the Assessment, the District conducted field-based surveys and inventories during the project planning process to determine current and desired-future stand conditions. Current stand data was used to determine where management could occur within the project areas in order to meet project objectives such as forest resiliency and achieving the District's ASQ targets. To inform project planning, evaluations of spotted owl habitat were also incorporated into the treatment designs and prescriptions. Of the 8,142 acres of proposed action, the highest proportion of the treatments within spotted owl habitat, 33 percent (2,714 acres), is planned within stands characterized as spotted owl foraging habitat (a subset of NRF habitat), followed by 25 percent (2,011 acres) in dispersal-only habitat, and then 16 percent (1,286 acres) in nesting-roosting habitat. Twenty-six percent (2,131 acres) of the proposed action is planned in lands that do not currently function as spotted owl habitat (i.e., capable or non-habitat). Table 3 below provides the amount of proposed vegetation treatment, road construction and landing construction by spotted owl habitat type.

**Table 3. Treatment Acres by Spotted Owl Habitat for Medford District BLM FY20 Batch of Projects.**

| Project | Field Office | NRF | | Dispersal-Only | Capable | Non-Habitat | Total |
|---|---|---|---|---|---|---|---|
| | | Nesting-Roosting | Foraging | | | | |
| **Bear Grub** | Ashland | 133 | 1,202 | 1,542 | 1,246 | 835 | **4,958** |
| **Round Oak** | Butte Falls | 1,153 | 1,512 | 469 | 43 | 7 | **3,184** |
| **TOTAL** | | **1,286** | **2,714** | **2,011** | **1,289** | **842** | **8,142** |

To balance the ecological need as described above (e.g. Figures 1-4), along with the District's and RMP management Direction and Objectives (2016 RMP/ROD) and ESA obligations, the District planned, to the extent practicable, the proposed action with the following strategies to avoid and minimize impacts to spotted owls (see Assessment, pp. 11-14).

**Harvest Land Base**

- Conduct timber harvest to contribute to the attainment of the declared Allowable Sale Quantity (ASQ) for the Medford Sustained Yield Unit (SYU) (HLB LUA) (pp. 62, 64, and 68).
- Utilize integrated vegetation management to promote the development and retention of large, open grown trees and multi-cohort stands; increase or maintain vegetative species diversity; promote and enhance the development of structural complexity and heterogeneity; adjust stand composition or dominance; reduce stand susceptibility to disturbances; and create growing space for hardwood and pine persistence and regeneration (at dry sites) (HLB-UTA LUA) (p. 68).
- Conduct regeneration harvest to reset stand development in stands that would not respond well to commercial thinning, and provide complex early-successional ecosystems (HLB-LITA LUA) (p. 64).
- Design timber harvest treatments in a manner sufficient to avoid incidental take of spotted owls (p. 121).
- Treat both management activity fuels and natural hazardous fuels to modify the fuel profile, reduce potential fire behavior and fire severity (p. 91).

**Late Successional Reserves (Bear Grub Only)**

- Promote the development of nesting-roosting habitat for the spotted owl that do not currently support northern spotted owl nesting and roosting (p. 70).
- Apply silvicultural treatments to speed the development of spotted owl nesting-roosting habitat or improve the quality of nesting-roosting habitat in the stand in the long-term (p. 72).

- Enable forests to: respond positively to climate-driven stresses, wildfire and other disturbance with resilience, and ensure positive or neutral ecological impacts from wildfire (p. 74).
- Contribute to the 17,000 acre decadal target (p. 74).
- Apply fuels treatments to reduce the potential for uncharacteristic wildfires (p. 75).
- Design timber harvest treatments in a manner sufficient to avoid incidental take (p. 121).

Under the proposed action, the removal and retention of all age and size classes (proportional thinning) helps achieve the stated RMP objectives for the LSR land use allocation. Here, the treatment objective is to reduce stand densities now so as to set the stand on a more desirable stand development trajectory to create a multiple canopy, multi-age stand for the future. These treatments would accelerate the development of forest stand conditions for northern spotted owl habitat and shift stand trajectories to encourage key habitat components for the future. Conversely, stands in which treatments are not applied would maintain a higher relative density and would remain in a homogenous and uniform stand structure of less complexity until a natural disturbance event takes place. For likely outcomes of the treatments, please see the Bear Grub Vegetation Management Project Environmental Assessment (pp. 24-32 and 76).

**Riparian Reserves**

- Conduct timber harvest and fuels reductions treatments to reduce the risk of stand-replacing crown fires and/or to ensure that stands are able to provide trees that would function as stable wood in the stream (RR-Dry LUA, Class 1 watershed) (pp. 82-84).

***Spotted Owl Considerations in Project Planning***

Effects to spotted owls were considered in project planning because timber harvest under the BLM's SWO RMP/ROD is expected to avoid incidental take of spotted owls until implementation of a barred owl management program is in place (USDI BLM 2016a, p. 30). In designing projects to minimize impacts to spotted owls, District wildlife biologists and silviculturists worked together to develop stand-level prescriptions consistent with the LUA management direction and spatial locate harvest units to reduce impacts to and likely avoid incidental take of spotted owls. This includes avoiding and minimizing impacts to currently occupied spotted owl sites as determined through current and ongoing surveys (USDI FWS 2012a) in the Bear Grub and Round Oak project areas. If spotted owls are located, the District will drop or modify the treatment prescriptions to avoid an incidental take determination by the Service. Take avoidance and/or project modification is consistent with Recovery Plan discretionary Recovery Action 10 where occupied sites will be avoided to the extent possible as well as conservation of higher quality habitat.

The projects were planned, to the extent practicable, consistent with the critical habitat rule for the spotted owl (USDI FWS 2012b) by utilizing the following concepts of Ecological Forestry (e.g. see Franklin and Johnson 2012 entire), for example, implement:

- Uneven-aged stand management (UTA) for fire resilience in the dry forest;
- Regeneration harvest with varying levels of retention in the Low Intensity Timber Area (moist forests types);
- Protection of larger and older trees within harvested areas;
- Thinning within the Late-Successional Reserve to speed the development of northern spotted owl habitat; and
- Retention of key forest structural components following natural disturbances in the reserves (USDI BLM 2016a, p. 23).

In addition to the Ecological Forestry concepts above, the District incorporated the following from the critical habitat rule in project planning:

1. While the management of spotted owls and their critical habitat are not the primary objectives for the treatments proposed in the HLB LUA of the Bear Grub project, the proposed silviculture objectives are to reduce stand densities to within the historic natural range to increase stand resilience, which is consistent with the critical habitat rule to restore natural ecological processes where they have been disrupted or suppressed (USDI FWS 2012b:71877). In addition, treatments proposed in LSR (Bear Grub only) would aim to accelerate the development of spotted owl nesting habitat, also consistent with the rule (USDI FWS 2012b, p. 71881).
2. If resident spotted owls are located, harvest units would be dropped or modified to avoid the likelihood of incidental take of spotted owls. Therefore, the proposed action is not anticipated to impact the demographic support role of the critical habitat sub-units (USDI FWS 2012b, p. 71881).

## Project Prescriptions

The FY20 Batch of Projects utilizes silviculture prescriptions for managing conifer forests to accomplish the project level objectives (Table 4). This includes prescriptions applied to each stand based on existing stand conditions, field based spotted owl habitat determinations, or in some cases, aerial photo/LiDAR interpretation by experienced BLM wildlife biologists. The Project's prescription writer and wildlife biologist will conduct field reviews and adjust marked trees, as necessary, prior to harvest to ensure prescription objectives and spotted owl habitat retention levels are met and consistent with this consultation (see USDI BLM 2015).

**Table 4. Acres of Vegetation Treatments and Road/Landing Construction for Medford District BLM FY20 Batch of Projects.**

| Treatment Type | Bear Grub | Round Oak | Total Acres |
|---|---|---|---|
| **Selection Harvest** | 1,433 | 987 | **2,420** |
| **Regeneration Harvest** | 0 | 1,629 | **1,629** |
| **Hazardous Fuels Reduction** | 3,460 | 544 | **4,004** |
| **Riparian Reserve Thinning** | 7 | 0 | **7** |
| **Road and Landing Construction, yarding wedges**[1] | 58 | 24 | **82** |
| **TOTAL** | **4,958** | **3,184** | **8,142** |

1- These only include acres from road and landing construction and yarding wedges that are outside of units or inside NR or F downgrade or NR, F, and Dispersal-only modification units.

**Prescriptions/Land Use Allocation/Project Area (copied from the Assessment, pp. 14-19)**

***Harvest Land Base – Low and Moderate Intensity Timber Areas (LITA and MITA)***

**Regeneration Harvest (RH) – Round Oak Only**

The primary purposes of implementing this treatment are to produce timber to contribute to the attainment of the declared ASQ and to create growing space for early-seral species (such as pine) persistence and regeneration and to provide a variety of forest structural stages distributed both spatially and temporally. Utilizing ecological forestry principles, up to15-30 percent of live conifer pre-harvest basal area (BA) would be retained in LITA and 5-15 percent would be retained in MITA. These would be retained in a variety of spatial patterns including aggregated groups and individual trees. Trees that are both ≥40 inches DBH and that the BLM identifies as having been established prior to 1850 would be retained as well, except where falling is necessary for safety or operational reasons and no alternative harvesting method is economically viable or practically feasible. If such trees need to be cut for safety or operational reasons, retain cut trees in the stand. After regeneration harvest, natural or artificial regeneration would be used to reforest a mixture of species appropriate to the site.

The proposed regeneration harvest prescription would remove nesting-roosting, foraging, and dispersal-only habitat (see Effects Table for acreage).

***Harvest Land Base - Uneven Aged Timber Area (UTA)* – Bear Grub and Round Oak**

While each project uses different terms for the prescriptions (commercial thinning, selection harvest), they will follow RMP UTA direction.

Projects would be treated with integrated vegetation management. **Integrated vegetation management** includes the use of a combination of silvicultural or other vegetation treatments, fire and fuels management activities, harvest methods, and **restoration** activities. Activities include, but are not limited to, vegetation control, planting, snag creation, prescribed fire, biomass removal, **thinning**, single tree **selection harvest**, and group selection harvest (USDI BLM 2016a, p. 68). In forested stands greater than 10 acres commercial treatments may consist of the following:

- Thinning treatments would be prescribed to achieve an average relative density between 20-45 percent after harvest.
- The retention of all dominant Douglas-fir and pine trees that are both greater than or equal to 36 inches diameter at breast height and were established prior to 1850
- The retention of all madrone, big leaf maple, and oak trees greater than or equal to 24 inches diameter at breast height
- At least 10 percent of the treatment unit would be retained in untreated “skips” to provide structural complexity and refugia.
- A total of 30 percent of the stand may consist of openings up to 4 acres, but not exceeding 4 acres each.
- For stands where the primary objective is to maintain dispersal-only habitat, Selection Harvest would be prescribed to achieve 40 percent canopy cover retention, as well as retaining other key habitat features to maintain dispersal function. For stands where the primary objective is to maintain NR or F habitat function, Selection Harvest would be prescribed to maintain 60 percent canopy cover and retain other key habitat features, such as canopy layering, large down woody material, basal area, and standing snags, and legacy structures, to maintain nesting and/or roosting foraging function. Additionally, no more than 20 percent of the pre-harvest basal area would be removed in the stands with prescriptions to maintain nesting-roosting habitat function.
- Prescribed fire may be used following mechanical treatments to stimulate vegetation, reduce fuel loading, and prepare the site for planting.

***LSR – Dry*** **– Bear Grub Only**

**LSRs** are Federal lands primarily dedicated to maintaining and promoting the development of habitat for the northern spotted owl. The LSR LUA is comprised of two sub-allocations: Dry Forest and Moist Forest. RMP direction for LSR and HLB appear similar in prescription, but diverge in objective. Treatments in LSR incorporate a more balanced ratio of harvest group selections (openings) and areas that are left as intact forest (skips), resulting in a more heterogeneous stand structure post-harvest For likely outcomes of the treatments, achieving RMP objectives for the LSR, please see the Bear Grub Vegetation Management Project Environmental Assessment (pp. 24-32 and 76).

**Selection Harvest**

Proposed treatments include Selection Harvest, which will follow the direction under the SWO RMP/ROD for LSR LUA as described below.

> Projects would be treated with integrated vegetation management. **Integrated vegetation management** includes the use of a combination of silvicultural or other vegetation treatments, fire and fuels management activities, harvest methods, and **restoration** activities. Activities include, but are not limited to, vegetation control, planting, snag

creation, prescribed fire, thinning, single tree selection harvest, and group selection harvest (USDI BLM 2016a, p. 68). In forested stands greater than 10 acres commercial treatments may consist of the following:

- Thinning treatments would be prescribed to achieve an average relative density between 20-45 percent after harvest.
- The retention of all dominant Douglas-fir and pine trees that are both greater than or equal to 36 inches diameter at breast height and were established prior to 1850.
- The retention of all madrone, big leaf maple, and oak trees greater than or equal to 24 inches diameter at breast height.
- At least 10 percent of the treatment unit would be retained in untreated "skips" to provide structural complexity and refugia.
- A total of 25 percent of the stand may consist of openings up to, but not exceeding 4 acres each.
- For stands where the primary objective is to maintain dispersal-only habitat, Selection Harvest would be prescribed to achieve 40 percent canopy cover retention, as well as retaining other key habitat features to maintain dispersal function. For stands where the primary objective is to maintain nesting-roosting or foraging function, Selection Harvest would be prescribed to maintain 60 percent canopy cover and retain other key habitat features, such as canopy layering, large down woody material, standing snags, and legacy structures, to maintain nesting and/or roosting foraging function.
- Prescribed fire may be used following mechanical treatments to stimulate vegetation, reduce fuel loading, and prepare the site for planting.
- In stands < 10 acres treated with selection harvest or commercial thinning, do not create group selection openings greater than 2.5 acres in size.

  When conducting commercial harvest create snags as identified in the SWO RMP/ROD (p. 73).

LSR prescriptions would vary, but could downgrade and remove foraging habitat and remove dispersal-only habitat as long as nesting-roosting habitat still maintains function at the stand level post-treatment (USDI BLM 2016, p. 70, 71). Foraging habitat in LSR would only be removed in low relative habitat suitability. LSR prescriptions could also modify nesting-roosting, foraging, and dispersal-only habitat, but would still maintain function post- treatment.

***Riparian Reserve* – (Commercial Thinning only in Bear Grub)**

Riparian Commercial Thinning would be applied in the Middle (50-120 feet of intermittent, non-fish-bearing streams) and Outer Zones (Site Potential Tree of fish-bearing, perennial, and intermittent streams) of the Riparian Reserve-Dry (RR) land use allocation (Class I sub-watershed). The primary objective is to reduce the risk of stand-

replacing, crown fires by reducing stand density and creating space between residual trees to reduce the potential for fire spread (USDI BLM 2016a, p. 83).

Commercial-sized (>8 inches DBH) conifer trees would be removed in addition to hardwoods >8 inches DBH, if necessary, to facilitate removal of conifer trees to meet the prescription. Generally, conifer tree removal would target the lowest size classes (8 inches DBH to 20 inches DBH) within the stand. Appropriate riparian species would be retained to maintain and improve diversity. The following retention preference for conifer species would be applied, where possible: sugar pine, ponderosa pine, incense cedar, Douglas-fir, and white fir. Treatments would maintain at least 30 percent canopy cover and 60 trees per acre expressed as an average across the treated portion of the RR (USDI BLM 2016a, p. 83). Existing snags >6 inches DBH and down woody material >6 inches in diameter at the large end and >20 feet in length would be retained unless removal is necessary for safety, operation, or fuels reduction reasons. Snags >6 inches DBH cut for safety or operational reasons would be retained as down woody material. In the Inner, Middle, or Outer Zones, a minimum of two new snags (1 >10 inches DBH and 1 >20 inches DBH) would be created within one year of completion of yarding the timber in the timber sale. If trees are not available in the size class specified, trees from the largest size class available would be used. Snag creation amounts would be met as an average at the scale of the portion of the harvest unit within the RR, and would not need to be attained on every acre (USDI BLM 2016a, p. 83).

Riparian thinning would remove nesting-roosting, foraging, and dispersal-only habitat (see Effects Table). All Bear Grub Riparian commercial thinning is proposed in mid seral closed and homogenous stand conditions.

> "Thinning these stands that are over stocked and contain mostly small Douglas-fir trees would increase the growth of desirable trees for the future and increase the number of large trees better suited as stable wood to the streams currently lacking structural complexity and riparian species diversity. Thinning these stands would help reduce the amount of Douglas-fir trees, while retaining those species less prominent in the stand to increase species diversity in the riparian zones. Also, thinning treatments would favor the retention of all size classes of trees and in turn would help promote more structural complexity in these stands" (Draft Bear Grub Vegetation Management Project EA pg. 8 of 76).

***Hazardous and Activity Fuels Reduction Treatments (all LUAs, including Riparian Reserves)***
**– Bear Grub and Round Oak**

**Fuels Treatment of Forest Management Activity Slash**
Activity fuels created from forest management activities described above would be treated post-harvest. To accomplish the fuels treatments, the BLM would conduct a fuels assessment within each unit following harvest activity to determine the fuel hazard and fire risk based on surface fuel loading, aspect, slope, access, and location of each unit. Post-harvest fuels treatments may include lop and scatter, selective slashing, hand pile burning, biomass removal, pre-commercial thinning, understory, thinning, and under-burning.

**Pre-Commercial Thinning (PCT)**
Pre-Commercial Thinning would include the cutting of understory vegetation and small trees (conifers less than 8 inches DBH and hardwoods less than 12 inches DBH) using chainsaws. Methods for disposing of the cut material are discussed below.

**Lop-and-Scatter**
When the slash (live and dead material 8 inches or less in diameter) remaining in the treatment units after harvest is less than 11 tons per acre, all stems and branches would be cut from the tree trunk and scattered. Trunks 7 inches in diameter and less would be cut to 3-foot lengths and left on the ground. Slash depth would not exceed 18 inches.

**Hand Piling, Mechanical Piling, and Pile Burning**
Hand piling and hand pile burning would occur when the slash remaining in the treatment units after harvest is greater than 11 tons per acre. Material between 1 and 7 inches in diameter, and longer than 2 feet, would be handpiled. The piles would be a minimum of 4 feet high and 6 feet in diameter. Piles would be burned in the fall, winter, or spring and would occur within 1 year or less of being piled.

Mechanical piling and pile burning would occur when the slash remaining in the treatment units after harvest is greater than 11 tons per acre and the slope is less than 35 percent. Mechanical equipment would pick up material and walk it to the pile. Material would not be pushed into a pile. Equipment would only travel on previously used skid trails. If machine piled, material between 2 and 12 inches in diameter and 2 feet long would be piled. The piles would be a minimum of 8 feet high and 10 feet in diameter. Most fuels treatments would begin within 90 days after completion of harvest activities. Piles would be burned in the fall to winter and burning of piles would occur within six months to 3 years of being piled.

**Underburning**
Underburning may be proposed in treatment units to treat residual slash and reduce fire hazard. In proposed treatment units, underburning would be used to remove at least 60 percent of slash less than 3 inches in diameter and a lesser amount of larger fuel size classes. Underburning would be implemented in the spring or fall. Treatment units are analyzed for possible underburning based on the anticipated amount of residual slash, resource objectives, strategic and logistical concerns (aspect, ridgetops, roads, proximity to other fuels treatments, values at risk, etc.). BLM fire and fuels management personnel would conduct post-treatment evaluations to determine the need for underburning.

Follow-up maintenance underburning may take place within five years following initial treatments. Underburning involves the controlled application of fire to understory vegetation and downed woody material when fuel moisture, soil moisture, and weather and atmospheric conditions allow for the fire to be confined to a predetermined area at a prescribed intensity to achieve the planned resource objectives. Prescribed underburning usually occurs during late winter to spring when soil and duff moisture conditions are sufficient to retain the required amounts of duff, large woody material, and to reduce soil heating. Occasionally, these conditions can be met during the fall season.

**Biomass Removal**

Whole trees or tree tops would be yarded to log landings, the tree tops and limbs removed and piled at the landings, and the resulting slash piles hauled away from the landings. Whole tree yarding and tree top yarding would not be required but are options for treating activity slash.

**Proposed Action Implementation Methods**

A variety of manual and mechanical methods will be used to implement the proposed action. These methods include ground-based, skyline-cable, and helicopter log extraction.

Polygons representing possible landing locations were included in the proposed units GIS layer used to determine effects from the proposed action. All landings occurring outside of proposed units or within units with prescriptions that would not remove spotted owl habitat were included in the analysis. Approximately 11 acres of NR and F (4 acres of NR and 7 acres of F) habitat would be removed from landing construction within the Bear Grub and Round Oak projects. Landing construction would remove approximately 24 acres of dispersal-only habitat (17 acres in Bear Grub and 7 acres in Round Oak). The habitat effects from the proposed landing construction are analyzed as a separate treatment area and have been incorporated into the total habitat effects for the project as habitat removal (Table 12). Openings created from proposed yarding corridors were assessed and added to the potential treatment effects determination for each unit (either modified and maintained habitat function or downgraded NR or F habitat). Per the timber sale contracts, yarding corridors are limited to 12 feet in width. The prescription writers/silviculturists work with logging systems foresters to determine where more basal area retention is needed to account for potential openings from yarding corridors, while still maintaining habitat function post-treatment. Additionally, the BLM would use one of the timber sale contract stipulations (L-24) to ensure canopy cover is retained, when necessary. The L-24 stipulation requires yarding corridors to be flagged prior to harvesting the unit and if previously reserved trees are needed for yarding corridors, a tree previously marked for harvest could be re-marked as reserve to replace the original reserved tree in the corridor. BLM contract administrators walk the flagged corridors and identify equivalent reserve trees in the unit if needed to replace marked reserve trees located in flagged corridors. The BLM contract administrator makes the final approval before the contractor is allowed to move forward with cutting and yarding operations along the corridors.

For the Bear Grub and Round Oak projects, known spotted owl nest tree locations were compared with the proposed cable units and this evaluation found that no known nest trees are located near potential guy line anchor or tailhold tree estimated paths or locations. Therefore, the BLM has determined that no known spotted owl nests would be removed as a result of tail hold or anchor trees. However, nest trees could get damaged by yarding cables. Spotted owl surveys are being conducted consistent with the spotted owl survey protocol, including surveys at known sites and proposed timber sale areas. If spotted owls are located, the BLM will evaluate the spotted owl locations relative to the logging systems and make changes as appropriate consistent with BLM authorities which could include modification to the logging systems or reducing the number of anchor trees.

The exact number of guyline or tailhold trees that would be cut in the proposed units is unknown, but the potential exists for several to be cut adjacent to each cable unit. Guyline or tailhold trees could be cut in nesting-roosting, foraging, dispersal-only, or non-habitat. Even though several trees could be cut, these stands adjacent to the harvest units are still anticipated to retain their current habitat function post-treatment because it is estimated that no more than three to six trees per landing would be cut. The total number of trees to be cut would depend on the amount of yarder settings/landings for each unit. The individual tree removal is not expected to have substantial reductions to the canopy cover or basal area, change multi-layer stand conditions (if they exist), or remove other key habitat components. The amount of individual trees that could be cut would not collectively change the current function of nesting-roosting, foraging, or dispersal-only stands in which they occur. BLM contract administrators inspect these guyline and tailhold trees while the timber sale is active and report findings to the wildlife biologist and other resource specialist. All landings need approval from the BLM contract administrator prior to them being cut. In some cases, the adjacent areas where the guylines are located do not qualify as habitat, and when single remaining trees are not present, dozers would be used as anchors. According to Oregon OSHA Regulations, felled trees would be removed from the site if they cannot be stabilized and pose an additional threat of sliding or rolling onto the roadways (OAR 437-007-0225 and OAR 437-007-0500). Potential guyline or anchor trees are not expected to occur in spotted owl nest patches.

Access to some units would require road construction to extract timber. The habitat effects from the road construction are analyzed as separate treatment areas if they are located outside of habitat removal units, and have been incorporated into the total habitat effects for the project as habitat removal (Table 12). The roads were buffered to create polygons to represent the effects from the road building. These buffers were included in the proposed units GIS layer used to determine effects from the proposed action. All road construction outside of proposed units or within NR or F downgrade, NR or F modified, or dispersal-only modified units were included in the analysis. Approximately 2 acres of foraging habitat and 4 acres of dispersal-only habitat would be removed by proposed route construction scattered throughout the Round Oak project. The proposed road construction in Bear Grub would not occur in spotted owl habitat.

For all of the activities included above, reinitiation of consultation would occur if the actual effects from these actions exceed the anticipated effects described in this consultation.

**Project Design Criteria**

Under the proposed action, conservation measures (also described as Project Design Criteria – PDC) are integrated into the project design to avoid and minimize potential adverse effects of the activity on listed species and critical habitat (Assessment, Appendix A, and Appendix B herein). In some cases, incorporation of these conservation measures into the project design may warrant a determination that the activity is *not likely to adversely affect* (NLAA) listed species or critical habitat.

The following conservation measures (including and in addition to PDCs from Appendix B herein) apply to all proposed activities considered in this Opinion unless a particular activity is

expressly exempted by a particular measure. As such, exemptions (if any) are described in the Assessment (pp. 20-24).

The District retains discretion to halt and modify all projects, anywhere in the process of project completion, should new information regarding effects to proposed and listed threatened or endangered species, or their Critical Habitat, arise. Minimization of impacts will then, at the least, include the application of an appropriate seasonal restriction to minimize disruption impacts; and could include clumping of retention trees around nest trees, establishment of buffers, dropping unit(s) or portions of units, or dropping entire projects. Also, should such a situation arise, the Level 1 Team will be convened to determine whether reinitiating consultation will be necessary.

If new spotted owl sites are located during surveys, BLM staff biologists and the Level 1 teams will review PDCs and the consultation to confirm the ESA analysis remains valid given the circumstances. Timber sales have a contract clause (E-3) that authorizes the District to initiate a stop work order to the timber sale contractor when threatened and endangered species are found in the timber sale or to comply with court orders. If or when listed species are found in the project area the timber operators would be notified in writing by the contracting officer to stop the work until the issue is evaluated further. If the impacts to the new site are no longer consistent with the analysis, the project will remain stopped until the BLM completes one or more of the following:

- Modifies the proposed action to ensure that impacts remain as described in the consultation documents.
- Imposes seasonal protections (if necessary).
- Reinitiates or completes new consultation.

**The following general PDC are expected to be implemented to the fullest extent practicable. If the PDC are not implemented as described or per agreed upon deviations between the Service and BLM, reinitation of consultation may be warranted.**

- Activities would be seasonally restricted between March 1 and July 15 within the disruption distances Seasonal Restrictions as described in Table B-1 in Appendix B
- Spotted owl protocol (USDI FWS 2012a) surveys are still ongoing at the time of this Assessment. Therefore, current occupancy information is not available for many of the sites but will be available prior to and/or concurrent with the on-the ground work. If spotted owls are located during remaining protocol surveys before the time of on the ground implementation, units would be dropped or modified to eliminate potential adverse effects that could lead to an incidental take determination. Survey results will be shared with the Level 1 at the end of each survey season to discuss the survey results and appropriate conservation measures.
- Wildlife biologists will review proposed activities through current field office project tracking procedures, which may include field reviews. The purpose of this involvement is to ensure the project minimizes impacts to listed species and the project is carried out as described in this consultation and supporting documents, including implementing seasonal restrictions and other PDC.

- The planning and implementation of Medford District projects will be consistent with the District's Planning and Implementation Quality Control Plan (2015) current at the time of project implementation. Note the Plan is periodically revised; project implementation will be consistent with the current plan. The citation provided here represents the current plan.
- Prescriptions designed to maintain nesting-roosting or foraging habitat function at the unit scale post-treatment would implement these project design criteria to ensure the function of the habitat and the conditions that would classify the stand as NR or F would remain post-treatment. Best available information from the Klamath Province and as summarized in USDA USDI 2013 informs the treatments and PDCs.
    - Nesting habitat would retain an average of 60 percent canopy cover. Generally no more than 20 percent of the existing basal area would be removed (Wagner and Anthony, 1998) in NR habitat. This includes having at least 180 $ft^2$/acre total basal area (balanced mix of conifer and hardwoods) retention. The wildlife biologist and prescription writer would review the NR (nesting) units to ensure habitat elements are retained to ensure the stands would still function as nesting habitat post-treatment.
    - Foraging stands would retain an average of 60 percent canopy cover and will have at least 150 $ft^2$/acre total basal area (balanced mix of conifer and hardwoods) retention. The wildlife biologist and prescription writer would review the foraging units to ensure habitat elements, including basal area and canopy cover, are retained to ensure the stands would still function as nesting habitat post-treatment.
    - Multiple canopy layers would be retained in stands with more than one layer present prior to treatment. These conditions are documented prior to treatment during habitat evaluations and/or silviculture stand exams. The mark inspection process includes the evaluation of how the mark impacts the layering and would be adjusted as needed to ensure pre-treatment layering is retained post-treatment.
    - Decadent components such as large snags, large character trees (live trees with deformities) large down wood, and large hardwoods, would be retained. Snags and danger/hazard trees that must be felled to meet Occupational Safety and Health Administration guidelines would be left on site, used for stream restoration, or sold, depending on the proximity to roads, streams, and the LUA.
    - In prescriptions that include the creation of small openings (gaps) and where the objective is to maintain habitat function, the openings would range from not be greater than one acre in size and would be distributed throughout the unit in a manner to retain sufficient canopy cover, basal area, and key habitat features as described above. The total acres of openings would not exceed 20 percent of the treatment area to maintain NR and F quality and canopy cover. Fewer openings would considered in units with additional thinning in order retain sufficient basal area and canopy cover.
    - Post-harvest fuels treatments, understory reduction, or pre-commercial thinning would only be done if the existing post-harvest layering (especially the lower

canopy layers) would not be removed as a result of the activity fuels treatments. The post-harvest layering conditions and need for additional understory treatments would be assessed by the project wildlife biologist, fuels specialist, and prescription writer.

- Prescriptions designed to maintain dispersal-only habitat function at the unit scale post-treatment would implement these project design criteria to ensure the function of the habitat and the conditions that would classify the stand as dispersal-only habitat would remain post-treatment. Best available information from the Klamath Province and as summarized in USDA USDI 2013 informs the treatments and PDCs.
    - Canopy cover in treated dispersal-only units would be retained at an average of 40 percent, which would provide the minimum canopy to function as dispersal-only habitat.
    - Decadent components important to owls, such as large snags, large down wood, and large hardwoods, would be retained. Snags or danger/hazard trees that must be felled for Occupational Safety and Health Administration guidelines would be left on-site, used for stream restoration, or sold, depending on the proximity to roads, streams, and the LUA.

- No known nest trees would be removed. In some situations with known sites, these are not based on having known nest trees but rather activity areas with spotted owl pairs and/or fledgling spotted owls. For example, no known nest trees are known for Bear Grub sites 0096O, 0971O, 2260B, and 3942O. In cases where actions are planned within these activity areas, like 0971O and 2260B, no large diameter trees (potential nest trees/structure) would be removed and only ground-level fuels treatments conducted. Similarly, for site 0096O and 39420, no potential nest trees would be removed and the proposed commercial thinning are on the edge of the nest patches, away from general vicinity were historic activity has been documented.

- Large standing snags and down wood will be retained in all project areas to meet the SWO RMP/ROD management direction (USDI BLM 2016a). Generally the marking guidelines favor the retention of large hardwoods and large deformed trees, which provide nesting opportunities for spotted owls. Snags and danger/hazard trees that must be felled to meet Occupational Safety and Health Administration guidelines would be left on site, used for stream restoration, or sold, depending on the proximity to roads, streams, and the LUA.

- The timber sale mark in proposed units that modify nesting-roosting or foraging habitat would be reviewed by the project wildlife biologist prior to implementation to ensure the prescription would retain the function of NR or F habitat post-treatment. The priority for review would be in the home ranges of occupied owl sites to ensure accurate implementation in the relatively more demographically meaningful areas for spotted owls. Foraging units retaining at least 150 $ft^2$/acre total basal area (conifer and hardwoods), would also be a high priority for review. The desired habitat retention stand conditions described in the definition section above would be checked in the field by the project area biologist and/or the prescription writer. Specifically the mark review would

include checking and documenting how the mark would affect the following stand/habitat elements: tree DBH, basal area, canopy cover, multi-layered structure (if present), skip placement, and gap sizes. Additional trees would be marked for retention if the field review indicated the habitat function (i.e. high canopy cover, layering, basal area, etc.) as intended in the prescription would not be retained post-harvest.

**Action Area**

The proposed 4,958 acre Bear Grub project is within three 5th field watersheds (Middle Applegate, Little Applegate, and Bear Creek watersheds). The proposed 3,189 acre Round Oak Project area is roughly split between two fifth-field watersheds, the South Fork of the Rogue River to the North and Big Butte watershed to the South. See further discussion of action areas below in Action Area section. The Bear Grub project is located in the Klamath Province whereas the Round Oak project is in the Cascades West Province.

## ANALYTICAL FRAMEWORK FOR THE JEOPARDY AND ADVERSE MODIFICATION DETERMINATIONS

### Jeopardy Determination for the Spotted Owl

Section 7(a)(2) of the Act requires that Federal agencies insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any listed endangered or threatened species. The analysis in this Biological Opinion relies on the following four components: (1) the Status of the Species, which evaluates the range-wide condition of the listed species addressed, the factors responsible for that condition, and the species' survival and recovery needs; (2) the Environmental Baseline, which evaluates the condition of the species in the action area, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the species; (3) the Effects of the Action, which determines the consequences of the proposed Federal action; and (4) Cumulative Effects, which evaluates the effects of future, non-federal activities in the action area on the species.

In accordance with policy and regulation, the jeopardy determination is made by evaluating the effects of the proposed federal action in the context of the species' current status, taking into account any cumulative effects, to determine if implementation of the proposed action is likely to cause an appreciable reduction in the likelihood of both the survival and recovery of the spotted owl in the wild.

The jeopardy analysis in this Biological Opinion emphasizes the range-wide survival and recovery needs of the listed species and the role of the action area in providing for those needs. It is within this context that we evaluate the significance of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

The project area is located within the Oregon Klamath Mountains and the West Cascades Physiographic Provinces and both provinces are recognized as recovery units in the Northern Spotted Owl Revised Recovery Plan (USDI FWS 2011). Pursuant to Service policy, when an

action impairs or precludes the capacity of a recovery unit from providing both the survival and recovery function assigned to it, that action may represent jeopardy to the species. When using this type of analysis, the biological opinion describes how the action affects not only the recovery unit's capability, but also the relationship of the recovery unit to both the survival and recovery of the listed species as a whole. For the spotted owl, when an action impairs or precludes the capacity of a recovery unit from providing both the survival and recovery function assigned to it, that action may represent jeopardy to the species at the range-wide scale.

The analysis in the following sections places an emphasis on consideration of the rangewide survival and recovery needs of the spotted owl and the relationship of the action area to the survival and recovery of the spotted owl at the rangewide and provincial scales as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

**Destruction or Adverse Modification Determination**

Section 7(a)(2) of the Act requires that Federal agencies insure that any action they authorize, fund, or carry out is not likely to destroy or to adversely modify designated critical habitat. A final rule revising the regulatory definition of "destruction or adverse modification of critical habitat" was published on August 27, 2019 (84 FR 44976); the final rule became effective on October 28, 2019 (84 FR 50333). The revised definition states: "Destruction or adverse modification means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species."

Past designations of critical habitat have used the terms "primary constituent elements" (PCEs), "physical or biological features" (PBFs) or "essential features" to characterize the key components of critical habitat that provide for the conservation of the listed species. The new critical habitat regulations discontinue use of the terms "PCEs" or "essential features," and rely exclusively on use of the term "PBFs" for that purpose because that term is contained in the statute. However, the shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs or essential features. For those reasons, in this Biological Opinion, references to PCEs or essential features should be viewed as synonymous with PBFs. All of these terms characterize the key components of critical habitat that provide for the conservation of the listed species.

Our analysis for destruction or adverse modification of critical habitat relies on the following four components: (1) the Status of Critical Habitat, which evaluates the rangewide condition of designated critical habitat for the listed species in terms of essential features, PCEs, or PBFs, depending on which of these terms was relied upon in the designation, the factors responsible for that condition, and the intended recovery function of the critical habitat overall; (2) the Environmental Baseline, which evaluates the condition of the critical habitat in the action area, the factors responsible for that condition, and the recovery role of the critical habitat in the action area; (3) the Effects of the Action, which determines all consequences to critical habitat that are caused by the proposed action on the essential features, PCEs, or PBFs and how those effects are likely to influence the recovery role of affected critical habitat units; and (4) Cumulative Effects,

which evaluates the effects of future, non-Federal activities in the action area on the essential features, PCEs, or PBFs and how those effects are likely to influence the recovery role of affected critical habitat units.

For purposes of making the DAM determination, the Service evaluates if the effects of the proposed Federal action, taken together with cumulative effects, are likely to impair or preclude the capacity of CH in the action area to serve its intended conservation function to an extent that appreciably diminishes the rangewide value of CH for the conservation of the listed species. The key to making that finding is understanding the value (i.e., the role) of the CH in the action area for the conservation/recovery of the listed species based on the *Environmental Baseline* analysis.

The following analysis places an emphasis on using the intended rangewide and provincial scale recovery functions of spotted owl critical habitat and the role of the action area relative to those intended functions as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the adverse modification determination.

Please note that a "may affect, likely to adversely affect" determination for spotted owl critical habitat that triggers the need for completing an adverse modification analysis under formal consultation is warranted in cases where a proposed Federal action will: (1) reduce the quantity or quality of existing spotted owl nesting, roosting, foraging (NRF), or dispersal habitat at the stand level to an extent that it would be likely to adversely affect the breeding, feeding, or sheltering behavior of an individual spotted owl; (2) result in the removal or degradation of a known spotted owl nest tree when that removal reduces the likelihood of owls nesting within the stand; or (3) prevent or appreciably slow the development of spotted owl habitat at the stand scale in areas of critical habitat that currently do not contain all of the essential features, but have the capability to do so in the future; such actions adversely affect spotted owl critical habitat because older forested stands are more capable of supporting spotted owls than younger stands. Adverse effects to an individual tree within spotted owl critical habitat will not trigger the need to complete an adverse modification analysis under formal consultation if those effects are not measurable at the stand level.

In the following sections, the jeopardy analysis for the spotted owl is presented first, followed by the adverse modification analysis for spotted owl critical habitat. The CONCLUSION section is then presented that provides the section 7(a)(2) determinations based on each of these analyses.

## ENVIRONMENTAL BASELINE

Regulations implementing the Act (50 CFR 402.02) define the environmental baseline as the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the

consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline.

## RANGE-WIDE STATUS OF THE NORTHERN SPOTTED OWL

Information pertaining to the status of the spotted owl is summarized below, but further information is provided in Appendix A (herein) on the biology, status, and distribution of the spotted owl.

### Demographic Information

Because current range-wide survey data are insufficient and/or not available to produce reliable estimates of the spotted owl's population size, demographic data are used to evaluate trends in spotted owl study area populations, and these trends are used as a surrogate to inform a characterization of the range-wide status of the spotted owl.

The most recent meta-analysis of spotted owl data was conducted in January of 2014 (Dugger et al. 2016). The analysis incorporated the long history of spotted owl data, which includes survey and banding data for the past 22 to 29 years (Appendix A).

In summary, Dugger et al. (2016) found declines in most demographic parameters. Their findings indicate that competition with barred owls are likely the key reason for range-wide declines, as apparent survival declines and local extinction rate increases were associated with the occurrence of barred owls. Additionally, authors noted a positive association between the removal of barred owls and the vital rates of spotted owls (Dugger et al. 2016, p. 98).

Declines in population change and occupancy rates were shown to have continued across the range, except in coastal California where barred owl removal project was started in 2009. In the Oregon and California study areas, realized rate of population change (the change in population since the study was initiated) has shown steady declines over the past two decades (Dugger et al. 2016, p. 72-74), including declines in the Klamath, Cascades, and Hoopa study areas, which were noted as stable in the previous meta-analysis (Forsman et al, 2011 as cited by Dugger et al. 2016, p. 91). Authors found strong evidence of declines in seven areas, and less evidence of declines in three (Tyee, Klamath and South Cascades) (Dugger et al., 2016, p. 70).

In summary, the key findings include the following:

- Spotted owl populations range-wide are declining at an average annual rate of 3.8 percent.
- Competition with barred owls are likely the primary cause of spotted owl population declines across their range because:
    - Barred owls have a strong negative effect on spotted owl survival on some but not all of the individual study areas.

    - Barred owls have a strong positive effect on spotted owl site extinction rates on all areas. Barred owls also have a strong negative effect on spotted owl colonization on some but not all study areas.
- Occupancy is declining on all individual study areas but at differing rates among the areas.
- Effects of climate/weather are variable on spotted owl vital rates. The effects are more evident range-wide in this analysis relative to the results of the previous meta-analysis (Forsman et al. 2011).
- Habitat loss is still concerning that is affecting spotted owl survival, extirpation, and colonization rates on some spotted owl demographic study areas.

**Habitat Conditions**

The current range-wide environmental baseline for spotted owl habitat can be obtained from two primary sources. The first source of range-wide nesting/roosting data can be obtained from the 20 Year NWFP Northern Spotted Owl Monitoring Report which evaluates remotely-sensed nesting/roosting habitat trends from 1994 through 2012 (Davis et al. 2016, Table 7; p. 22).

This recent report illustrated variable rates of habitat loss depending on land allocation, ownership, and Provincial location. Range-wide there was a gross loss of about 650,200 acres of nesting/roosting habitat on federal lands (Davis et al. 2016, Table 6), which represents about 7.2 percent of what was present in 1993. Habitat loss on federal lands from timber harvesting represents 25 percent of what was anticipated. Most of the overall losses (73 percent) occurred within the federally reserved land use allocations, or a loss of about 7.5 percent of the habitat reserved by the NWFP. The majority of these losses occurred in the California and Klamath Physiographic Provinces, largely resulting from the effects of high severity fires (Davis et al., 2011, p. iii; Davis et al. 2016, pages 23, 35-38). Forest succession is resulting in habitat recruitment that has compensated somewhat for some of these losses from disturbances; therefore, the net decrease of habitat is less than the gross decrease as represented by the values presented above. However, these younger mature stands are primarily developing after clearcut logging and generally lack structural legacies from previous stands.

The second source of information is the more inclusive USFWS Tracking and Integrated Logging System database (TAILS), which includes a component for tracking the effects to NRF habitat (by physiographic province and ownership type), based on site-specific consultation-related impacts to habitat from land management and natural disturbance events from 2012 to present. The TAILS database also incorporates the effects to foraging habitat, where field units are able to discern these often distinct habitats; though they may or may not be included in the remotely-sensed and classified "NR" layers. These data are entered typically after completion of consultation. Since 1994, 759,992 acres of NRF have been reported removed or downgraded from management actions, and 414,199 acres have been reported removed or downgraded from wildfires or other natural causes, private timber harvest [through Habitat Conservation Plans or Safe Harbor permits] (see Appendix A, Table A-1).

**Threats to the Continued Existence of the Spotted Owl**

The recent best available information strongly indicates that barred owl competition may be the most pressing threat (USDI FWS 2013 and Dugger et al. 2016, p. 112) influencing spotted owls (see Competition between Spotted Owls and Barred Owls in the Effects section). The potential for management to mitigate the impacts of barred owls may be effective for maintaining occupied northern spotted owl sites and enabling northern spotted owls to recolonize historic sites that have been occupied by barred owls (Diller et al. 2016, p. 11 and Wiens et al. 2020). While not occurring in the action areas, over 2,000 barred owls have been removed under the experimental removal study (USDI FWS 2013 and Wiens et al. 2020). Results of the experimental removal will inform future barred owl management efforts across the range of the spotted owl, including BLM managed lands.

The effects of extensive past habitat loss and degradation caused by timber harvest, past and ongoing effects of wildfires are additive and are also influencing the current range-wide condition of the spotted owl (USDI FWS 2011, p. vi.).

Glenn et al. (2010, p.2551) noted that the potential consequences of global climate change on Pacific Northwest forests remain somewhat unclear, though there is potential for changes in forest composition and disturbance patterns that could affect northern spotted owl populations. Most models predict warmer, wetter winters and hotter, drier summers for the Pacific Northwest in the first half of the 21st century (Mote and Salathé 2010, Figure 7, pp. 39-41). More recently, Mote and others (2014, p. 489) found similar temperature trends but varying precipitation trends depending on scenarios. These changes will likely exacerbate some existing threats such as the effects of past habitat loss as a result of tree mortality caused by drought-related fires, insects and disease, and increases in extreme flooding, landslides and wind-throw events in the short-term (10 to 30 years) (Mote et al. 2014, p.494). While a change in forest composition or extent is likely a result of climate change, the rate of that change is uncertain. Large scale high-severity fires were found to initiate rapid ecological state changes at local and stand-level spatial scales (Crausbay et al. 2017) suggesting forest transformation could likely occur over the long term. Others have noted that in forests with long-lived dominant tree species some forest components can survive these stresses, so direct effects of climate on forest composition and structure would most likely occur over a longer time scale (100 to 500 years) in some areas than disturbances such as wildfire or insect outbreaks (25 to 100 years) (McKenzie et al. 2009, pp. 319-338).

While not a threat identified at the time of listing, exposure to contaminants and other factors associated with marijuana cultivation is now recognized as a growing concern for northern spotted owls, especially in the California Coast and California and Oregon Klamath Provinces (see additional information in *Exposure to Toxicants*, Appendix A), which are recognized as important areas for northern spotted owl populations (Schumaker et al. 2014). Numerous forms of toxicants used in marijuana cultivation threaten wildlife. Herbicides and highly toxic, second-generation anticoagulant rodenticides (ARs) are commonly used to prevent grasses and small mammals from damaging the crop (Thompson et al. 2013 entire, Gabriel et al. 2013, entire). Recently, wildlife exposure to a wide range of toxicants found on illegal cannabis grow sites on private timberlands, wilderness areas, and Tribal land in Northern California were documented between 2012 and 2016, where soluble and liquid fertilizers, organophosphates, carbamates,

rodenticides, pyrethroids, avermectins, molluscicides and strychnine alkaloids were found at 76 independent locations (Gabriel 2017). In this same area, 70 percent of northern spotted owls and 40 percent of barred owls tested positive to one or more anticoagulant rodenticides (Gabriel et al 2018). These findings suggest that contaminants represent a concern for the spotted owl's survival.

## ENVIRONMENTAL BASELINE FOR THE OREGON KLAMATH AND THE OREGON WEST CASCADES PHYSIOGRAPHIC PROVINCES

### Spotted Owl Demographics

The Medford District FY20 Batch of Projects occur within the Oregon Klamath and the Oregon West Cascades Physiographic Provinces. Actual population data for the Provinces are not available. However, the Oregon Klamath Province (and a small proportion of the Oregon South Cascades Province) intersects with portions of the Klamath East and Klamath West Modeling regions analyzed in the final critical habitat rule. Together, these two modeling regions were determined to contain 934 spotted owl sites (USDI FWS 2011, p. C-20-21, Table C-3). Using the above estimate for both modeling regions and assuming pair occupancy (from 2008 data), an estimated 1,868 spotted owls would have occurred in the East and West Klamath modeling regions. Incorporating data from 2009-2013, Dugger et al. 2016, found annual declines in the Klamath, Southern Cascades, and Northwestern California study areas ranging -2.8 to -3.7 (Table 4, p. 70). Applying the mean annual rate of decline (-3.17) from the estimated 2008 population to the time prior to the 2017 fires, we estimate the current population to have approximately 1,300 spotted owls in the Klamath East and Klamath West modeling regions, including updates from recent consultations (on file with the Service). However, this is likely optimistic estimate because we assume continued declines in pair occupancy and that the annual rate of decline has continued since 2013, the last year of data analyzed for the meta-analysis. Data from other administrative units are not available for spotted owl sites no longer viable after the 2017 fires nor does this account for the unknown number of spotted owls lost from toxicant exposure in the California Klamath province (see Gabriel et al. 2018). However, as provided in the Effects section below, the BLM will not implement projects that incur incidental take of spotted owls. As a result, the population estimate provide above is not anticipated to be reduced in any appreciable manner due to the proposed action.

In addition to the meta-analysis described above, we are also utilizing the results of local demographic analyses from the Klamath Demographic Study Area (KLA) for the South Cascades Demographic Study Area (CAS) to evaluate the current condition of the spotted owl population for the local environmental baseline. The KLA is located within the Oregon Klamath Mountains Physiographic Province in Southwestern Oregon and occurs across the BLM checkboard ownership pattern adjacent to the action areas. The CAS is located on Forest Service managed lands to the east of the actions areas with some overlap with the Round Oak action area. Both the KLA and CAS are relatively large and the precipitation patterns and forest composition are representative of the action areas (Anthony et al. 2006). Because of the similarities, we assume demographic data from the KLA and CAS are likely representative of, or somewhat comparable to, the spotted owl population condition in the action areas. However, we recognize that the differences in size, land ownership patterns, and recent natural and

anthropomorphic disturbances may influence differences in demographic performance to an unknown extent (see Hollen et al. 2016, p. 3, Lesmeister et al. 2018, p. 3, ) likely influence spotted owls.

In recent years, findings from both the KLA and CAS suggest steady declines in the number of pairs and non-juveniles and declines in overall occupancy, survival, reproduction, and fecundity (Lesmeister et al. 2020, entire and Dugger et al. 2019 entire). The most recent report for the KLA found the number of sites with pair occupancy has declined every year since 2005. In 2019, at least one spotted owl in 20 of the 161 sites in the study area (12.4 percent), with 8 sites occupied by pairs (five percent) (Lesmeister et al. 2020, pp. 2-4). Similarly, the CAS has experienced a declining trend in occupancy with 12 percent of the sites occupied with at least one spotted owl in 21 of the 171 sites surveyed in the study area (10 percent spotted owl pair occupancy) in 2019 (Dugger et al. 2019, p. 14 [issued February 2020]). Under the RMP, it was modeled and anticipated that spotted owl populations would continue to decline precipitously and be locally extirpated across the range. This was largely due to due to barred owl competition regardless of how much habitat is conserved and unless the barred owl threat is addressed.

**Spotted Owl Habitat**

The current environmental baseline for spotted owl habitat can be obtained from two primary sources. The first source of range-wide and provincial nesting/roosting data can be obtained from the 20 Year NWFP Northern Spotted Owl Monitoring Report which evaluates remotely-sensed nesting/roosting habitat trends from 1994 through 2012 (Davis et al. 2016, Table 7; p. 22). Based on this report, the Oregon Klamath province is estimated to consist of 1,175,300 acres, accounting for a loss of 85,500 acres from harvest and 136,800 from wildfire and other natural disturbance events. The Oregon West Cascades province is estimated to consist of 2,710,700 acres, accounting for a loss of 225,100 acres from harvest and 71,200 acres from wildfire and other natural disturbance events. The second source of information is the more inclusive USFWS Tracking and Integrated Logging System database (TAILS), which includes a component for tracking the rangewide NR (nesting, roosting) habitat baseline (by physiographic province and ownership type), including site-specific consultation-related impacts to habitat from land management and natural disturbance events from 2012 to present. The TAILS database also incorporates the effects to foraging habitat, where field units are able to discern these often distinct habitats; though they may or may not be included in the remotely-sensed and classified “NR” layers. These data are entered typically after completion of consultation. NR habitats measured from the 2012 range-wide baseline of 9,003,781 acres, this database reports that the Oregon Klamath Province currently consists of approximately 934,566 acres and accounts of a loss of 16,675 acres due to management activities and an additional loss of 45,344 acres due to natural disturbance events, such as wildland fire since 2012. The same table reports the Oregon West Cascades currently consists of approximately 2,374,071 acres and accounts of a loss of 14,463 acres due to management activities and an additional loss of 16,513 acres due to natural disturbance events, such as wildland fire since 2012 (Appendix A, Table A-2). This information represents the most current and best available information on the provincial and range-wide condition of spotted owl habitat.

Generally, the current conditions of forested stands in the province reflect an area characterized by very high climatic and vegetative diversity resulting from the regime of mixed-fire severity, steep gradients of elevation, dissected topography, mixed soil types, range of precipitation. As a result, the forests in the Klamath and southern and western Oregon Cascades region support highly diverse mix of vegetation types with compositional diversity and spatial heterogeneity at the stand, landscape, and regional levels (Spies et al., 2007 entire). The vegetational diversity translates to a diverse prey base for spotted owls in the action area, but generally dominated by woodrats (*Neotoma sp.*) and northern flying squirrels (*Glaucomys sabrinus*) (Carey and Biswell. 1992, p. 242, Carey et al. 1999, pp. 73-76; Forsman et al. 2004, p. 219). On federally managed lands, the most common nesting structure used by spotted owls in the Oregon portion of this province include Douglas-fir mistletoe platforms or some type of cavity nest on federally managed lands (as summarized *in* Courtney et al. 2004:5-26).

## ENVIRONMENTAL BASELINE FOR THE ACTION AREAS

### Description of the Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). In delineating the action area, we evaluated the farthest reaching physical, chemical, and biotic effects of the action on the environment.

For northern spotted owls, the action area is usually based on the radius of a circle that would approximate the provincial home range, which is 1.3 miles for the Klamath Mountains Province and 1.2 in the West Cascades Province (Thomas et al. 1990 and Courtney et al. 2004). The Bear Grub Project is in the Klamath Province and the Round Oak Project is in the West Cascades Province. Therefore, the action area represents all lands within 1.2 and 1.3 miles of proposed treatment units and all lands within any overlapped associated provincial home ranges of known spotted sites that could be directly, indirectly or cumulatively impacted by the proposed action. The action areas for all projects are displayed in the maps in Assessment Appendix D. Tables 5 and 6 below provide habitat baseline data for the action areas.

### Status of Northern Spotted Owl Habitat in the Action Area

The baseline tables below summarize spotted owl habitat by ownership, land use allocation, and critical habitat in for the Bear Grub and Round Oak Action Areas (Tables 5 and 6). The District used the Medford District spotted owl habitat baseline layer for BLM managed lands and the updated 2014 Rogue Basin habitat layer based on GNN (Gradient Nearest Neighbor) data to type habitat on non-BLM land (NRF, dispersal-only, capable, and non-habitat).

The Medford District BLM spotted owl habitat baseline, which is updated annually by District staff, is current as of February, 2020 (Assessment, p. 26), incorporates impacts from previous fires and suppression actions, and represents best available information.

The majority of the spotted owl habitat updates for the project units within the proposed Bear Grub and Round Oak treatment units were based on field evaluations. These field evaluations included taking measurements of overstory canopy cover (ocular estimates), measuring overstory

tree diameters, recording the number of canopy layers, recording the amount of coarse woody debris and snags, and recording other habitat characteristics such as nesting platforms, cavities, and mistletoe brooms. In addition to the field evaluations, the project wildlife biologists conducted a review of potential spotted owl habitat using a combination of aerial photographs, LiDAR, GIS software, wildlife survey data, and stand exam records for the remaining project units. Areas outside of proposed treatment units were updated using aerial photos or LiDAR. As a result, the habitat baseline for the Bear Grub and Round Oak projects represents the most current and up-to-date habitat information to the extent practicable, and overall, this habitat information represents best available information.

### Bear Grub Action Area

The Bear Grub Action Area is contained in one large polygon, at 78,028 acres, and does not overlap with the Round Oak Action Area. Approximately 25 percent of the federal lands within the action area are NRF habitat (Table 5). The habitat in the action area is influenced by geology, with meadows or oak woodlands on many of the south facing slopes. Historic fire has also influenced the habitat, with the most recent large fire occurring in 2002 (Squires Peak). There are 25 spotted owl home ranges within the action area (Table 8).

**Table 5. Spotted Owl Habitat Environmental Baseline for the Bear Grub Action Area, Medford District BLM.**

| | Total Acres | NRF Habitat Acres (% Total) | Capable Habitat Acres (% Total) | Reserved Acres[1] (% Of Total) | Non-Reserved Acres (% Of Total) | Dispersal[2,] Acres (% Of Total) |
|---|---|---|---|---|---|---|
| **OWNERSHIP** | | | | | | |
| **-All Ownerships** | 78,028 | 17,669 (23%) | 28,358 (36%) | 27,211 (35%) | 50,817 (65%) | 37,783 (48%) |
| **- Non-Federal (Private, State)** | 34,460 | 6,774 (20%) | 12,094 (35%) | 0 | 34,460 (100%) | 17,097 (50%) |
| **-Federal (BLM, USFS )** | 43,568 | 10,897 (25%) | 16,266 (37%) | 27,211 (62%) | 16,357 (38%) | 20,686 (47%) |
| **LAND ALLOCATION—FEDERAL** (*hierarchal, no acres double-counted*) | | | | | | |
| **Reserves** | 27,211 | 6,544 (24%) | 9,973 (37%) | 27,211 (100%) | 0 | 10,942 (40%) |
| **Harvest Land Base (and Matrix on FS)** | 16,357 | 4,353 (27%) | 6,293 (38%) | 0 | 16,357 (100%) | 9,738 (60%) |

**SPOTTED OWL CRITICAL HABITAT**

| Critical Habitat Unit | Sub-unit | Acres | NRF Habitat Acres | Capable Habitat Acres | Reserved | Non-Reserved | Dispersal |
|---|---|---|---|---|---|---|---|
| **10** | **KLE-3** | 616 | 97 (16%) | 250 (41%) | 299 (49%) | 317 (51%) | 243 (39%) |
| **10** | **KLE-6** | 18,007 | 6,867 (38%) | 4,675 (26%) | 9,979 (55%) | 8,028 (45%) | 11,980 (67%) |

Notes: 1. Based on 2016 RMP LUAs BLM and 1994 NWFP LUA FS Reserved= land allocation with no programmed timber harvest, but some removal of commercial trees, including LSR, Riparian Reserve, and District Designated Reserves in this AA 2. Dispersal includes NRF habitat. See DEFINITIONS section above habitat descriptions.

### Round Oak Action Area

The Round Oak Action Area is contained in one large polygon, at 57,737 acres and does not overlap with the Bear Grub Action Area. Approximately 39 percent of the federal lands within the action area are NRF habitat (Table 6). There are 18 spotted owl home ranges within the action area (Table 8).

**Table 6. Spotted Owl Habitat Environmental Baseline for the Round Oak Action Area, Medford District BLM.**

| | | Total Acres | NRF Habitat Acres (% Total) | Capable Habitat Acres (% Total) | Reserved Acres[1] (% Of Total) | Non-Reserved Acres (% Of Total) | Dispersal[2,] Acres (% Of Total) |
|---|---|---|---|---|---|---|---|
| **OWNERSHIP** | | | | | | | |
| **-All Ownerships** | | 57,737 | 13,807 (24%) | 16,487 (29%) | 6,748 (12%) | 50,989 (88%) | 37,928 (66%) |
| **- Non-Federal (Private, State)** | | 28,234 | 2,266 (8%) | 10,262 (36%) | 0 | 28,234 (100%) | 15,297 (54%) |
| **-Federal (BLM, USFS)** | | 29,503 | 11,541 (39%) | 6,225 (21%) | 6,748 (23%) | 22,755 (77%) | 22,001 (75%) |
| **LAND ALLOCATION—FEDERAL** (*hierarchal, no acres double-counted*) | | | | | | | |
| **Reserves (BLM, USFS)** | | 6,748 | 3,448 (51%) | 1,060 (16%) | 6,748 (100%) | 0 | 5,321 (79%) |
| **Harvest Land Base (matrix FS)** | | 22,755 | 8,093 (36%) | 5,165 (23%) | 0 | 22,755 (100%) | 16,680 (73%) |
| **SPOTTED OWL CRITICAL HABITAT** | | | | | | | |
| **Critical Habitat Unit** | **Sub-unit** | **Acres** | **NRF Habitat Acres** | **Capable Habitat Acres** | **Reserved** | **Non-Reserved** | **Dispersal** |
| **10** | **KLE-4** | 8,203 | 3,171 (39%) | 1,376 (17%) | 1,257 (15%) | 6,946 (85%) | 6,822 (83%) |
| **10** | **KLE-5** | 6,354 | 2,884 (45%) | 856 (13%) | 1,656 (26%) | 4,698 (74%) | 5,228 (83%) |

Notes: 1 Based on 2016 RMP LUAs BLM and 1994 NWFP LUA FS Reserved= land allocation with no programmed timber harvest, but some removal of commercial trees, including LSR, Riparian Reserve, and District Designated Reserves in this AA 2. Dispersal includes NRF habitat. See DEFINITIONS section above habitat descriptions.

Fifth field watersheds can provide a landscape-level qualitative evaluation for dispersal function using the concepts of Thomas, et al (1990), as described below, along with more recent analyses of dispersal function per Lint, et al. (2005), Davis, et al. (2011 and 2016). Davis, et al. (2016) suggested that landscapes having at least 40 percent of dispersal habitat conditions (including both older and younger closed canopy forests) would be sufficient to support spotted owl dispersal across the landscape. For the fifth field watershed scale analysis conducted in this consultation, the District used the updated habitat information as described above to characterize NRF, dispersal-only, capable, and non-habitat across the region and across all ownerships (Table 6). This information represents the best available habitat data and analysis approach to evaluate dispersal-habitat function for spotted owls. The effects to spotted owl dispersal from the Bear Grub and Round Oak projects are analyzed in the Effects section below.

**Table 7. Dispersal Habitat Conditions in the Fifth Field Watersheds Associated with the Bear Grub and Round Oak Projects, Medford District BLM.**

| 5th Field Watershed | Associated Project (s) | Total Watershed Acres | Total NRF Habitat Acres | Total Dispersal-Only Habitat Acres | Total Dispersal Acres (NRF+ Dispersal Only) | % Watershed Dispersal Habitat (NRF +Dispersal-only) |
|---|---|---|---|---|---|---|
| **Bear Creek** | Bear Grub | **231,067** | 37,126 | 56,786 | 93,912 | **41 %** |
| **Big Butte Creek** | Round Oak | **158,137** | 41,136 | 65,061 | 106,197 | **67 %** |
| **Little Applegate River** | Bear Grub | **72,245** | 22,245 | 20,322 | 42,567 | **59 %** |
| **Middle Applegate River** | Bear Grub | **82,537** | 20,986 | 22,739 | 43,725 | **53 %** |
| **South Fork Rogue River** | Round Oak | **160,657** | 64,727 | 57,314 | 122,041 | **76 %** |

**Status of Northern Spotted Owl Sites in the Action Area**

Northern spotted owl site occupancy is defined as locations with evidence of continued use by spotted owls (including breeding), repeated location of a pair or single birds, presence of young before dispersal, or some other strong indication of continued occupation. Spotted owl sites used in this consultation are based on historic information, protocol surveys, or incidental observations (Assessment, Appendix C and Table 16 herein). Spotted owls are generally monogamous and primarily mate for life (Courtney 2004). They are also known to exhibit high site fidelity. However, owls often switch nest trees and use multiple core areas over time, possibly in response to fluctuations of prey availability, loss of a particular nest tree, or presence of barred owls (see the barred owl section below). These multiple nest locations (original and alternates) are typically combined to represent one spotted owl pair territory for analysis purposes. For this analysis, survey history was used to determine which location had the preponderance of activity (original or alternate locations, or both) to represent the final territory used for analysis (Assessment, p. 29).

As mentioned above, the action area represents all lands within 1.2 and 1.3 miles of proposed treatment units and all lands within any associated provincial home ranges of known spotted sites that could be directly, indirectly or cumulatively impacted by the proposed action. There are 43 known spotted owl site home ranges (including 3 territories with original and alternate site locations) that could be impacted by proposed projects in the Assessment (Assessment Table 8 and Assessment Appendix B). These home ranges are completely contained within the Bear Grub and Round Oak Action Areas because they overlap project unit footprints. There are 16 spotted owl site centers outside of the action areas with a portion of their home range overlapping the action areas. However, no treatments are proposed within these home ranges and these sites are further discussed in the Effects section.

**Table 8. Spotted Owl Sites Associated with the Bear Grub and Round Oak Action Areas, Medford District BLM FY20 Batch of Projects.**

| | Bear Grub | Round Oak | Total |
|---|---|---|---|
| **Number of Owl Home Ranges Completely Contained in the Action Area** *(proposed units in known home ranges)* | 25 | 18[1] | 43 |
| **Number of Owl Home Ranges Overlapping the Action Area** *(site center outside of AA and no units inside known home ranges)* | 12 | 4 | 16 |
| **TOTAL** | **37** | **22** | **59** |

*1* – Includes 3 territories with 1 alternate location/home ranges

**Spotted Owl Site/Home Range Habitat Conditions**

The pre-treatment NRF habitat acres for spotted owl sites in the Bear Grub and Round Oak project Action Areas are displayed in Table 16 herein and inform the effects determinations from the proposed actions. NRF habitat is a focus of the analysis because research has indicated that the quantity and configuration of "older forest" (analogous to NRF habitat) provides a valid inference into the likelihood of occupancy (Hunter, et al. 1995), survival, and reproduction (Franklin, et al. 2000; Zabel, et al. 2003; Olson, et al. 2004; Dugger, et al. 2005; Dugger, et al. 2011).

**Spotted Owl Habitat Outside of Known Spotted Owl Home Ranges**

There are approximately 3,527 acres of NRF habitat on federal lands within the Bear Grub and Round Oak Action Areas that are outside of known spotted owl home ranges (Table 9).

**Table 9. Spotted Owl NRF Habitat on Federal Lands Outside of Known Spotted Owl Home Ranges, but within the Bear Grub and Round Oak Action Areas for the Medford District BLM FY20 Batch of Projects.**

| Project Action Areas | NRF Acres |
|---|---|
| **Bear Grub** | 1,984 |
| **Round Oak** | 1,543 |
| **TOTAL** | **3,527** |

These NRF acres include aggregations of habitat that have potential for spotted owl occupancy. Contiguous NRF habitat greater than 70 acres (Miller et al., 1989) is one factor to determine if owls are present and based on threshold models developed by Swindle, et al. (1997) and Perkins (2000) that indicate the 200- to 300-meter radius (and sometimes greater), encompassing up to 70 acres around a nest is important to spotted owls. Additionally, contiguous NRF habitat located in high relative habitat suitability (RHS) (see USDI FWS 2011) have a higher potential of supporting spotted owls. Abiotic factors represented in the high RHS, such as slope, aspect, and core habitat, increase the likelihood of supporting nesting owls compared to other locations across the landscape.

**Spotted Owl Surveys**

All nesting-roosting and foraging habitat associated with the Bear Grub and Round Oak projects will be surveyed to protocol (USDI FWS 2012a and Lint et al. 1999), on BLM lands within 1.2 (Round Oak) and 1.3 (Bear Grub) miles of the proposed units and within spotted owl sites affected by the proposed action. These surveys include nesting-roosting and foraging habitat outside spotted owl known home ranges in the areas that have the highest potential for spotted owl occupancy, as determined by the District and informed by the information provided above. Spot check surveys will continue as needed according to the protocol. If spotted owls are located, the BLM will modify or drop the units as appropriate to avoid incidental take of spotted owls. See Assessment Appendix B for a summary of the survey efforts and survey results for the known spotted owl sites associated with Bear Grub and Round Oak projects.

**Northern Spotted Owl Prey Species**

The composition of the spotted owl's diet varies geographically and by forest type. Generally, flying squirrels are the most prominent prey for spotted owls in Douglas-fir and western hemlock forests in Washington and Oregon (USDI FWS 2011). In southwest Oregon, dusky-footed woodrats (*Neotoma fuscipes*) and northern flying squirrels (*Glaucomys sabrinus*) are a primary prey species for spotted owls (Forsman et al. 2004). Dusky-footed woodrats are typically found in high densities in early-seral or edge habitat (Sakai and Noon 1993; Bingham and Noon 1997), but are also abundant in old growth and complex forests (Carey, et al. 1997). Northern flying squirrels are another major source of owl prey in southwest Oregon, and are found in older, more structurally complex forest along with younger stands (Wilson 2010). Other important prey items include red tree voles, deer mice, red-backed voles, gophers, snowshoe hare, bushy-tailed wood rats, birds, and insects, although these species comprise a small portion of the spotted owl diet (USDI FWS 2011).

**Barred Owls**

The 2011 Revised Recovery Plan for the Northern Spotted Owl identifies competition from the barred owl as a threat to the spotted owl (USDI FWS 2011). Barred owls (*Strix varia*) are native to eastern North America, but have moved west into spotted owl habitat. Existing evidence suggests that barred owls compete with northern spotted owls for habitat and prey with near total niche overlap and that interference competition (Dugger, et al. 2011; Van Lanen, et al. 2011; Wiens et al. 2014) is resulting in increased northern spotted owl site abandonment, reduced

colonization rates, and likely reduction in reproduction (Olson, et al. 2005; Dugger, et al. 2011; Forsman, et al. 2011; Wiens et al. 2014).

Barred owls are detected opportunistically because the BLM does not conduct barred owl surveys across the District (Table 10). However, the District assumes the increasing trend of barred owl observations across the District, is consistent with the trends in the adjacent demography study areas. These additive impacts are discussed further in the Competition between Spotted Owls and Barred Owls in the Effects section.

While the BLM did not specifically survey for barred owls, a study in the Oregon Coast range suggests that over the course of a season, spotted owl surveys to protocol (> 3 visits) allow ~85 percent of the barred owls present in the area to be detected (Wiens et al. 2011). Additionally, the spotted owl survey protocol (USDI FWS 2012a) allows for a reasonable assurance that spotted owls in an area will be detected, even where barred owls are present. The Service and cooperators conducted analyses of historical spotted owl survey data, leading to estimates of detection rates for spotted owls that account for the effects of barred owl presence. These detection rates, along with data on spotted owl site colonization and extinction probabilities, and empirical analysis of spotted owl site occupancy, were utilized in developing the survey protocol used by the BLM in the Project Area. Use of the 2012 Protocol serves two primary purposes: (1) provide a methodology that results in adequate coverage and assessment of an area for the presence of spotted owls, and (2) ensure a high probability of locating resident spotted owls and identifying owl territories that may be affected by a proposed management activity, thereby minimizing the potential for unauthorized incidental take (USDI FWS 2012a). This represents best available information and approach to determining spotted owl residency/occupancy.

**Table 10. Barred Owl Detections within the Bear Grub and Round Oak Action Areas, Medford District BLM FY20 Batch of Projects.**

| Project | Spotted Owl Sites with Barred Owl Detections *(within the last 2 years)* | Percent of Total Spotted Owl Sites in the Action Area with Barred Owls | Additional Barred Owl Observations in the Action Area/ Comments |
|---|---|---|---|
| **Bear Grub** | **14 sites** 0096O, 0097O, 0114O, 0592O,0944O, 0973A, 0992O, 2361O, 2395O, 2397O, 3648O, 3942O, 4066O, 4611O | 56 % | 0 |
| **Round Oak** | **10 Sites** 1826B, 1831A/1831O, 1957B/1957F, 1958A, 2059A/2059O, 2359O, 2360A, 3260O, 4079O, 4616O, 4620O, FS-DD, FS-OM | 56% | 30 |

As mentioned above, experimental removal of barred owls suggest a positive demographic response by spotted owls (Diller et al. 2016 and Wiens et al. 2020). Experimental removal of barred owls is currently occurring in four study areas across the range of the spotted owl (USDI FWS 2013). The Union Myrtle Study Area (UMSA) is one of the four proposed long-term northern spotted owl study areas designed to assess the effects of barred owl removal on the status and trends in northern spotted owl as directed under Recovery Action 29 in the Revised

Recovery Plan (USDI FWS 2011). The KLA is being used as a control area (non-removal) for the UMSA, including areas within the Medford District. Results from the experimental removal will inform barred owl management options across the range of the spotted owl, including BLM lands.

## Status of Northern Spotted Owl Critical Habitat

Section 4(a)(3) of the ESA specifies that the Service shall designate critical habitat for endangered or threatened species and may, from time-to-time thereafter as appropriate, revise such designation. Critical habitat is defined as (1) specific areas within the geographical area occupied by the species at the time it is listed, on which are found those physical or biological features that are essential to the conservation of the listed species and which may require special management considerations or protection, and (2) specific areas outside the geographical area occupied by the species at the time it is listed that are essential for the conservation of a listed species.

Critical habitat for the northern spotted owl was first designated in 1992 in *Federal Register* 57 (USDI FWS 1992), and includes the primary constituent elements that support nesting, roosting, foraging, and dispersal. Designated critical habitat also includes forest land that is currently unsuitable, but has the capability of becoming NRF habitat in the future (USDI FWS 2012b, pp. 1796-1837). Critical habitat was revised for the northern spotted owl and the final designation was published by the Service in the *Federal Register* (signed on August 12, 2008) and became effective on September 12, 2008 (USDI FWS 2008). The 2008 Service's Critical Habitat delineations were challenged in court and the 2008 designation of northern spotted owl CHU was remanded. The Service was ordered to revise the CHU designation. The final Critical Habitat Rule was published in the *Federal Register* on December 4, 2012 (USDI FWS 2012, pp. 71876-72068) and became effective January 3, 2013. The rule continues to be litigated with a case pending in the District Court of Columbia.

Considerations in designating spotted owl Critical Habitat (USDI FWS 2012b) included the following:

- Ensuring sufficient habitat to support stable, healthy populations across the range, and also within each of the 11 recovery units;
- Ensuring distribution of spotted owl populations across the range of habitat conditions used by the species;
- Incorporating uncertainty, including potential effects of barred owls, climate change, and wildfire disturbance risk; and
- Recognizing that these protections are meant to work in concert with other recovery actions, such as barred owl management.

Four Critical Habitat sub-units (KLE-3, KLE-4, KLE-5, and KLE-6) are partially located within the action areas encompassing 33,180 acres of designated spotted owl Critical Habitat across all ownerships (Tables 5 and 6), which is 0.3 percent of designated spotted owl Critical Habitat range-wide (9,577,342 acres). Of the lands within spotted owl Critical Habitat in the action areas, 73 percent (24, 273 acres) are dispersal quality habitat (NRF plus dispersal-only habitat)

and 39 percent (13,019 acres) are NRF habitat (Tables 5 and 6). There are an additional 631 acres of spotted owl Critical Habitat on lands managed by the State of Oregon within the Bear Grub Action Area.

**Essential Physical or Biological Features of Critical Habitat**

The Physical or Biological Features (PBFs) are the specific elements considered essential to the conservation of the spotted owl and are those elements that make areas suitable as nesting, roosting, foraging, and dispersal habitat. The PBFs should be arranged spatially such that it is favorable to the persistence of populations, survival, and reproductive success of resident pairs, and survival of dispersing individuals until they are able to recruit into a breeding population (USDI FWS 2012b: 71904). Within areas essential for the conservation and recovery of the spotted owl, the Service has determined that the PBFs are:

1) **Forest types** that may be in early, mid-, or late-seral states and support the northern spotted owl across its geographical range

2) Habitat that provides for **nesting and roosting**. This habitat must provide:
   a) Sufficient foraging habitat to meet the home range needs of territorial pairs of northern spotted owls throughout the year.
   b) Stands for nesting and roosting that are generally characterized by:
      (i) Moderate to high canopy cover (60 to over 80 percent),
      (ii) Multilayered, multispecies canopies with large (20–30 in. [51-76 cm] or greater dbh) overstory trees,
      (iii) High basal area (greater than 240 $ft^2$/acre [55 $m^2$/ha]),
      (iv) High diversity of different diameters of trees,
      (v) High incidence of large live trees with various deformities (e.g., large cavities, broken tops, mistletoe infections, and other evidence of decadence)
      (vi) Large snags and large accumulations of fallen trees and other woody debris on the ground, and
      (vii) Sufficient open space below the canopy for northern spotted owls to fly.

3) Habitat that provides for foraging (F), which varies widely across the northern spotted owl's range, in accordance with ecological conditions and disturbance regimes that influence vegetation structure and prey species distributions.

4) Habitat to support the transience and colonization phases of dispersal, which in all cases would optimally be composed of nesting, roosting, or foraging habitat (PBFs (2) or (3)), but which may also be composed of other forest types that occur between larger blocks of nesting, roosting, and foraging habitat. In cases where nesting, roosting, or foraging habitats are insufficient to provide for dispersing or nonbreeding owls, the specific dispersal habitat PBFs for the northern spotted owl may be provided by the following:
   a) Habitat supporting the transience phase of dispersal, which includes:

(i) Stands with adequate tree size and canopy cover to provide protection from avian predators and minimal foraging opportunities; in general this may include, but is not limited to, trees with at least 11 in. (28 cm) dbh and a minimum 40 percent canopy cover; and

(ii) Younger and less diverse forest stands than foraging habitat, such as even-aged, pole-sized stands, if such stands contain some roosting structures and foraging habitat to allow for temporary resting and feeding during the transience phase.

b) Habitat supporting the colonization phase of dispersal, which is generally equivalent to nesting, roosting, and foraging habitat as described in PBFs (2) and (3), but may be smaller in area than that needed to support nesting pairs.

For the Bear Grub and Round Oak projects combined, approximately 2,178 acres of the proposed treatments in this Assessment occur in northern spotted owl habitat (nesting-roosting [PBF 2], foraging [PBF 3], and dispersal-only [PBF 4]) within the 2012 Revised Designated Northern Spotted Owl Critical Habitat (USDI FWS 2012b, pp.71876-72068) (Table 18). A portion of the Bear Grub project units (1,387 acres) are within Critical Habitat Unit 10 (sub-units KLE-3 and KLE-6). A portion of Round Oak project units (1,122 acres) are within Critical Habitat Unit10 (sub-unit KLE-5). Although the action area includes land in sub-unit KLE-4, no proposed treatment units occur in this sub-unit.

The following descriptions for CHU 10 and the associated sub-units where proposed treatments occur (KLE-3, KLE-5, and KLE-6) are directly out of the final rule in the *Federal Register* (USDI FWS 2012b, pp.71931-71935). The number of historical spotted owl sites for each sub-unit are from local BLM and Forest Service database and GIS queries.

**Unit 10: Klamath East (KLE)**

Unit 10 contains seven subunits and consists of the eastern portion of the Klamath Mountains Ecological Section M261A, based on section descriptions of forest types from Ecological Subregions of the United States (McNab and Avers 1994, Section M261A), and portions of the Southern Cascades Ecological Section M261D in Oregon. This region is characterized by a Mediterranean climate, greatly reduced influence of marine air, and steep, dissected terrain. Franklin and Dyrness (1988, pp. 137-149) differentiate the mixed-conifer forest occurring on the "Cascade side of the Klamath from the more mesic mixed evergreen forests on the western portion (Siskiyou Mountains)," and Kuchler (1977) separates out the eastern Klamath based on increased occurrence of ponderosa pine. The mixed-conifer/evergreen hardwood forest types typical of the Klamath region extend into the southern Cascades in the vicinity of Roseburg and the North Umpqua River, where they grade into the western hemlock forest typical of the Cascades. High summer temperatures and a mosaic of open forest conditions and Oregon white oak (*Quercus garryana*) woodlands act to influence northern spotted owl distribution in this region. Northern spotted owls occur at elevations up to 1,768 m. Dwarf mistletoe provides an important component of nesting habitat, providing additional structure and enabling northern spotted owls to occasionally nest within stands of relatively younger, small trees.

**KLE-3**

The KLE-3 subunit occurs in Jackson, Josephine, and Douglas Counties, Oregon, and comprises Federal lands managed by the USFS and the BLM under the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for east-west connectivity between subunits and critical habitat units, but also for demographic support. This subunit facilitates northern spotted owl movements between the western Cascades and coastal Oregon and the Klamath Mountains.

There are approximately 100 total historic spotted owl site centers located on BLM lands in this entire critical habitat sub-unit. This critical habitat sub-unit is not within lands managed by the Forest Service as indicated in the Final Critical Habitat rule language.

**KLE-5**

The KLE-5 subunit occurs in Jackson County, Oregon, and comprises lands managed by the BLM. Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for north-south connectivity between subunits, but also for demographic support.

There are approximately 40 total historic spotted owl site centers located on BLM lands in this entire critical habitat sub-unit. This critical habitat sub-unit is not within lands managed by the Forest Service as indicated in the Final Critical Habitat rule language.

**KLE-6**

The KLE-6 subunit consists of Federal lands managed by the BLM and USFS in Jackson County, Oregon, and Siskiyou County, California. Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for north-south connectivity between subunits, but also for demographic support.

There are approximately 80 total historic spotted owl sites on BLM and FS lands in Oregon in this entire critical habitat subunit.

### Northern Spotted Owl Critical Habitat Baseline

Table 11 summarizes the spotted owl habitat baseline for the entire critical habitat subunits KLE-3, KLE-5 and KLE-6. The Service created the habitat baseline acres by clipping the NWFP Interagency Regional Monitoring Program Spotted Owl habitat layer to the December 2012 critical habitat layer. The Service then created a spreadsheet on December 19, 2012 with the baseline habitat acres by CHUs and subunits. For this consultation, the District used the February 10, 2020 USFWS updated critical habitat acres for the current CH habitat baseline for

subunits. These acres were derived by subtracting spotted owl habitat removed by habitat-altering projects and fires entered into the USFWS database from the December 19, 2012 layer. Project specific habitat determinations are based on field verification, GIS habitat layers, and photo interpretation. Table 11 the most recent status of critical habitat, May 02, 2020. Any variation in acres from previous tables provided for this consultation are minor and discountable.

**Table 11. Critical Habitat Baseline (acres) for the units that overlap the Medford District BLM FY20 Batch of Projects.**

| CHU/ Subunit | NRF | Dispersal-Only | Dispersal (NRF + Dispersal-Only) | Capable or Non-Habitat | Total (Dispersal + Capable + Non-Habitat) |
|---|---|---|---|---|---|
| 10-KLE-3 | 37,627 | 43,694 | 81,321 | 31,476 | 112,797 |
| 10-KLE-5 | 18,233 | 13,044 | 31,277 | 6,974 | 38,251 |
| 10-KLE-6 | 44,807 | 88,136 | 132,943 | 34,906 | 167,849 |

* Source May 02, 2020 USFWS ECOS TAILS Report.

## Role of the Action Area in the Survival and Recovery of the Spotted Owl

NRF habitat within the action area covers 17,669 acres and dispersal-only habitat covers 37,783 acres; these values represent approximately less than one percent each of nesting-roosting habitat (12,733,533 acres total [Davis et al. 2016 as cited in USDI FWS 2016, p. 503]) and dispersal habitat range wide (9,120,287 acres total [Davis et al. 2016 as cited in USFWS 2016, p. 503]) for the spotted owl. Within the action areas, there are 43 known spotted owl sites and based on ongoing (yet-to-be completed) surveys to date, only 2 of these sites have been occupied by a resident spotted owls in the last two years.

As provided above, the District's combined action areas occur within the Oregon Klamath and Oregon West Cascades Physiographic Provinces. These provinces have been noted as an important area for spotted owl conservation. For example, Schumaker et al. (2014, pp. 585-587 and Figures 3 and 4) describe the spotted owls in the Oregon and Cascade Physiographic Province (modeling regions) as likely "source" populations for surrounding provinces, with the Klamath modeling region, overall, serve as a principal zone of productivity for spotted owl populations. Schumaker et al. (2014, p. 589) suggests that protecting and enhancing performance in both sources and sinks may be essential for range-wide population persistence.

These provinces are also identified as Recovery Units in the *Revised Recovery Plan for the Spotted Owl* (USDI FWS 2011, p. III-1). The intended function of these Recovery Units, inclusive of the action areas, are to support high quality spotted owl NRF and dispersal habitats. Specific to the Klamath Province, it was noted as threatened with ongoing habitat loss as a result of wildfire and the effects of fire exclusion on vegetation change (USDI FWS 2011, p. I-8, III-7). Findings from the 20-year NWFP report confirm these findings (Davis et al. 2016). To respond to these threats to old forests in the Klamath province, the Service recommended that landscapes:

> "… be actively managed in a way that reconciles the overlapping goals of spotted owl conservation, responding to climate change and restoring dry forest ecological structure, composition and processes, including wildfire and other disturbances."

As described in Davis et al. 2016, the southern and western Oregon Cascades, which include Dry Forests, are impacted by large scale wildfire as well, and result in loss of spotted owl habitat.

Consequently, District actions that result in positive or negative impacts to spotted owls and/or spotted owl habitat in the action area may impact the spotted owl across its range.

**BLM Resource Management Plan**

The FY20 Batch of Projects were planned consistent with the BLM's Southwestern Oregon Resource Management Plan (SWO RMP/ROD) (USDI BLM 2016a) (see INTRODUCTION section above). Specifically, the HLB LUA is intended for the harvest of timber and timber products produced from these projects would be sold in support of the District's Allowable Sale Quantity (ASQ) declared in the 2016 Medford District RMP (USDI BLM 2016a) (Assessment, pp. 1). A portion of the proposed action is also planned with the LSR. The proposed action is consistent with RMP LSR objectives in maintaining habitat and enhancing forest resiliency. The proposed action is also consistent with the RMP in avoiding incidental take of spotted owls. Currently occupied sites are not subject to NRF habitat removal. The RMP was consulted on with the Service and with conclusions as described above. Embedded in the 2016 RMP, the District is implementing discretionary conservation recommendations from the Northern Spotted Owl Recovery Plan (USDI FWS 2011) (as discussed in the Recovery Plan section below).

**SPOTTED OWL RESOURCE USE**

This section is provided in advance of the *Effects of the Action on the Spotted Owl* section to provide some important contextual information that helps to inform that analysis.

Because complete range-wide population surveys for the spotted owl are not available, it is a well-established analytical approach to analyze the effects of proposed activities on the spotted owl based on the extent, duration, and timing of habitat-altering activities and how those alterations are likely to affect spotted owl nesting, roosting, foraging, and dispersal behavior based on known spatial and habitat use relationships exhibited by the spotted owl (see USDI BLM et al. 1994, Lehmkuhl and Raphael 1993, Meyer et al. 1998, and Courtney et al. 2004). The anticipated amount of forest habitat likely to be used by spotted owls is based on the known range of habitat conditions used by spotted owls for nesting, roosting, and foraging (see Thomas et al. 1990 and Courtney et al. 2004). In addition, the basis for a finding that a proposed action is likely to significantly impair the breeding, feeding, sheltering and/or dispersal of affected spotted owls relies on the scientifically-recognized range of habitat conditions that are known to adequately provide for spotted owl life history requirements.

Spotted owls exhibit clear, consistent patterns of habitat association, and these patterns can provide the foundation for assessing the potential effects caused by land management activities. In the 1990 *Conservation Strategy for the Northern Spotted Owl,* the Interagency Scientific Committee (Thomas et al. 1990) stated that:

> "With the exception of recent studies in the coastal redwoods of California, all studies of habitat use suggest that old-growth forests are superior habitat for northern spotted owls. Throughout their range and across all seasons, spotted owls consistently concentrated their foraging and roosting in old-growth or mixed-age stands of mature and old-growth trees....Structural components that distinguish superior spotted owl habitat in Washington, Oregon, and northwestern California include: a multilayered, multispecies canopy dominated by large (>30 inches DBH) conifer overstory trees, and an understory of shade-tolerant conifers or hardwoods; a moderate to high (60-80 percent) canopy closure; substantial decadence in the form of large, live coniferous trees with deformities-such as cavities, broken tops, and dwarf mistletoe infections; numerous large snags; ground cover characterized by large accumulations of logs and other woody debris; and a canopy that is open enough to allow owls to fly within and beneath it."

Fifteen years later, the conclusions of the Interagency Scientific Committee were echoed in the *Scientific Evaluation of the Status of the Northern Spotted Owl* (Courtney et al. 2004), which found that the habitat attributes identified by Thomas et al. (1990) remain important components of spotted owl habitat. Notably, positive relationships were found with the aforementioned attributes whether the samples of spotted owl and random locations were within old-growth forest, non-old growth forest, National Parks, public land, or private land. In 2011, the Revised Recovery Plan again reiterated the association of spotted owls with older forest conditions, stating: "Spotted owls generally rely on older forested habitats (Carroll and Johnson 2008) because such forests contain the structures and characteristics required for nesting, roosting, and foraging."

### Spotted Owl Spatial Use of Forest Landscapes

A major advance in our understanding of spotted owl habitat relationships from Thomas et al. (1990) to the present is that we now have a much better understanding of the spatial scale of habitat selection (see Hunter et al. 1995, Meyer et al. 1998, Zabel et al. 2003) and the relationships of habitat to spotted owl fitness (Franklin et al. 2000, Olson et al. 2004, Dugger et al. 2005). Generally, for management activities addressing territorial organisms is typically spatially explicit and such activities are applied to an area corresponding to the movements and activity patterns of the individuals of the organism occupying the territory(ies). Spotted owls are territorial raptors that range widely in search of prey but are 'anchored' during the breeding season to a nest site (Rosenberg and McKelvey 1999). That is, spotted owls are a central-place forager. Foraging close to the nest reduces travel time and energetic expenditures of adults and also increases the ability of the adults to remain nearby and protect their young. Several studies have shown that spotted owls optimize selection of their nest sites to maximize the amount of older forest habitat close to the nest (see Ripple et al. 1991, Ripple et al. 1997, Swindle et al. 1999, and Perkins 2000) in addition to selecting habitat on a larger landscape basis (Ripple et al. 1997 and Swindle et al. 1999). On that basis, evaluations of spotted owl spatial use of an area and habitat are most meaningfully conducted at two spatial scales: the home range and core-use area, recognizing that habitat selection at a larger home range scale is likely dependent on the smaller core-use area (see Johnson 1980 for hierarchy of habitat selection).

The home range is the "area traversed by the individual in its normal activities of food gathering, mating, and caring for young" (Burt 1943:351). Within home ranges, areas receiving concentrated use, typically surrounding the nest site and favored foraging areas, are called core areas (Bingham and Noon 1997). Establishing the exact spatial extent of a spotted owl's home range and core area based on relative use within a home range typically requires use of radio-telemetry. Because of the intensity and high cost of radio-telemetry, action agencies are not able to conduct this type of study for specific projects. Therefore, for the purposes of assessing a project's potential impacts to the spotted owl, the Service approximates circles of similar size to the provincial median home range and core-use area estimates of spotted owls (see home range estimates in Thomas et al. 1990 and reaffirmed in Courtney et al. 2004), centered on spotted owl nest sites or activity centers (see below).

There are numerous analytical techniques for estimating home range sizes based on animal locations (reviewed in Powell 2000). For estimating median annual home range size of spotted owl pairs in Oregon (and elsewhere in the spotted owl's range), the estimator typically used was the minimum convex polygon or MCP method (Thomas et al. 1990 and USDI FWS 1992). Because the MCP estimates are generally large (as compared to other methods), they provide relatively conservative values on which to base the outer habitat-analysis area in that they include distant but likely important patches of habitat in such home ranges.

Spotted owls are central place foraging animals in that areas closer to the nest site receive disproportionally greater use (Rosenberg and McKelvey 1999). Resources such as food and breeding and resting sites can be patchily distributed in heterogeneous landscapes, such as those prevalent throughout the NWFP provinces. In such landscapes, animals are likely to disproportionately use areas that contain relatively high densities of important resources (Powell 2000), with concentrated use close to their nests. These disproportionately used areas are referred to as "core areas" (Bingham and Noon 1997). Thomas et al. (1990) found that amounts of suitable habitat within 0.7 miles (986 acres) of spotted owl activity centers were important to spotted owl life history functions, and that the amount of suitable habitat around nest sites was significantly greater than the amount of suitable spotted owl habitat in random circles. Schilling et al. (2013) found similar results for spotted owls in southwest Oregon in that the probability of stand use decreased with increasing distances from the nest area.

The findings of Thomas et al. (1990) illustrate the importance of the amount of suitable habitat within a spotted owl territory to support the life history requirements of the spotted owl. The results of subsequent studies (see below) have also indicated that a 0.5-mile radius circular area encompassing 500 acres around spotted owl activity centers is likely a more appropriate scale at which to evaluate the amounts of habitat required by breeding spotted owls (USDI FWS 2009 and USDI FWS 2011b Appendix A). These studies relied on three primary sources of information to support the 500-acre core area size: (1) the distribution of locations of radio-telemetered spotted owls; (2) the territorial spacing patterns of spotted owls; and (3) the results of studies comparing relative habitat selection by spotted owls at different scales (see Appendix-Status of the Species, Habitat Use and Selection).

Based on best available information, we are utilizing the documented spotted owl spatial use patterns of home range and core-use areas to inform potential project effects to the species. Due

to the impracticality of conducting radio-telemetry on each individual owl potentially affected, the Service uses circles as surrogates for approximating spotted owl home range and core-use areas to inform impacts to the species. It is recognized that spotted owls may adjust the shape of their home ranges to encompass as much older forest habitat as possible (Carey et al. 1992). As such, the use of circles may not correspond exactly with the areas used by spotted owls and may be more defined by other factors such as topographic features (e.g., drainages), abundance and availability of prey species, and the distribution and/or abundance of competitors and predators (Anthony and Wagner 1998, pp. 5-6, 1-17; summarized by Courtney et al. 2004, pp. 5-4 through 5-7). However, the practice of using circles has a biological basis (Lehmkuhl and Raphael 1993), and has been utilized by many researchers (Thomas et al. 1990, Ripple et al. 1991, Lehmkuhl and Raphael 1993, Ripple et al. 1997, Swindle et al. 1999, Perkins 2000, Franklin et al. 2000, Olson et al. 2004, Dugger et al. 2005) by providing a uniform method for quantifying (comparing/contrasting) spotted owl habitat. Use of circles, as opposed to other shapes (i.e., square, rectangles, etc.) imposes no bias on what is included or excluded for analysis. The use of circles also seems appropriate for species, like the spotted owl, characterized as a "central place species" and provides a simple unbiased measure of habitat availability at multiple ecologically-relevant scales surrounding spotted owl sites. The use of circles, as described herein that correspond to minimum convex polygon (MCP) estimates (and used interchangeably) should be large enough to include habitat to meet all major life history needs and include areas important to both members of most pairs.

Based on the median MCP home range estimate for spotted owl pairs, the following estimate by NWFP Province will help inform a spotted owl spatial analysis for the Klamath Province with 3,398 acres or a circle with a 1.3- mile radius. Within a home range, the smaller core-use area estimate of 500 acres or a circle with a 0.5 mile radius will inform the spotted owl core-use area analysis (Thomas et al. 1990, USDI FWS 1992, Carey et al. 1992, Anthony and Wagner 1998, Irwin et al. 2000, Courtney et al. 2004, Glenn et al. 2004 and USDI FWS 2011a). For purposes of this analysis, the core-use/home range area circle(s) will be centered on a spotted owl activity center that represents the area that spotted owls are likely to use for nesting and foraging in any given year. In situations where there is local information available on home range and core-use areas, those estimates should be given consideration for use.

**Habitat Availability in Spotted Owl Core Areas and Home Ranges**

Best available information indicates that spotted owl sites that are occupied over the long-term are positively associated with mosaics of forest habitat at the provincial core-use area and home range scales that are capable of providing the resources necessary to meet the essential life functions of individual spotted owls.

**Core Area**

Recently developed habitat-fitness (see below) and landscape models and other publications have demonstrated the validity of the core-use area and the importance of having sufficient amounts of NRF habitat within spotted owl core areas to adequately provide for spotted owl survival and reproduction, and access to prey (Franklin et al. 2000, Olson et al. 2004, Dugger et al. 2005, Zabel et al. 2003). Best available information to date indicates that spotted owl survival

and fitness are positively correlated with large patch sizes of older forest or large forest patches containing a high proportion of older forest (Franklin et al. 2000, Olson et al. 2004 and Dugger et al. 2005). Habitat-based fitness, or habitat fitness potential (HFP), is the "fitness conferred on an individual occupying a territory of certain habitat characteristics" (Franklin et al. 2000). HFP is function of both the survival and reproduction of individuals within a given territory. For example, the data sets analyzed by Franklin et al. (2000) were re-analyzed to evaluate the relationship between HFP and the simple proportion of older forest within spotted owl core-use areas. The results of that analysis (USDI FWS 2007, Appendix D), indicate a quadratic relationship between spotted owl HFP and older forest conditions, with optimum HFP occurring when approximately 50 percent of the estimated core area consisted of older forest (Franklin et al. 2000). More than half (55 percent) of the high-quality (with a HFP greater than 1) spotted owl territories had core areas comprised of 50 to 65 percent older forest. In a similar study in southern Oregon, Dugger et al. (2005) found that spotted owl HFP was positively related to the proportion of older forest in the core area, although the strength of the relationship decreases with increased proportions. Roughly 72 percent of core areas with a HFP greater than 1.0 had more than 50 percent older forest; whereas core areas with a HFP of less than 1.0 never contained more than 50 percent older forest.

Collectively, researchers have reported a wide range (ca. 35 to 60 percent) of mean proportions of older forest at the core area scale around spotted owl nests in southwest Oregon and northwest California (Hunter et al. 1995, Ripple et al. 1997, Meyer et al. 1998, Franklin et al. 2000 and Dugger et al. 2005). It is difficult to assess how much of this variation was due to differences in ecological setting, spatial scale, habitat classification, and individual variation among owls. Nonetheless, the central tendency of these results was roughly 50-60 percent older forest habitat within spotted owl core-use areas. The best available information suggests that older forest is more likely than other vegetation classes to provide the spotted owl with suitable structures for perching and nesting, a stable, moderate microclimate at nest and roost sites, and visual screening from both predators and prey.

**Annual Home Range**

Bart (1995) evaluated the suggestion in the 1992 draft recovery plan for the spotted owl (USDI FWS 1992) that at least 40 percent of the estimated home range be retained as suitable habitat. Using demographic data from throughout the spotted owl's range, including Oregon, Bart (1995) calculated that spotted owl populations are stable when the average proportion of NRF habitat in the home range is 30 to 50 percent. Olson et al. (2004) found for their Oregon Coast Ranges study area that mid and late-seral forest is important to spotted owls, but also found that a mixture of these forests with early seral forest improved spotted owl productivity and survival. Spotted owl demography and the presence of spotted owls appear to be positively associated with an intermediate amount of horizontal heterogeneity in forest habitat at the home range scale (Schilling et al. 2013); findings reported in more recent papers (see USDI FWS 2009) have been consistent with those of Bart (1995).

**Site Occupancy**

Habitat-based assessments have been used in various studies to estimate the presence (occupancy) of breeding spotted owls; these tools are important for evaluating the species-habitat relationships. Bart (1995) reported that occupied spotted owl core areas contained at least 30 to 50 percent mature and old growth forest and spotted owl demographic performance, particularly occupancy, increases with increasing amounts of NRF habitat in the core area. Meyer et al. (1998) examined landscape indices associated with spotted owl sites versus random plots on BLM lands throughout Oregon. Across provinces, landscape indices highly correlated with the probability of spotted owl occupancy included the percent of older forest (approximately 30 percent) within the 500 acres (analogous to a core area) surrounding the site (and this predictive value decreased with increasing distance) and that territory occupancy decreased following the harvest of NRF habitat in the vicinity of the affected core area. Zabel et al. (2003) found for their northwest California study area that the highest probability of spotted owl occupancy occurred when the core area is comprised of 60 - 70 percent nesting/roosting habitat. Stepping up to the larger home range scale, Thomas et al. (1990), Bart and Forsman (1992), Bart (1995), Olson et al. 2004, and Dugger et al. (2005) suggest that when spotted owl home ranges are comprised of less than 40 to 60 percent NRF habitat, they were more likely to have lower occupancy and fitness. It should also be noted that many spotted owl sites on BLM managed lands in southwest Oregon have historically been occupied by spotted owls, having less habitat than described in the above studies (USDA FS/USDI BLM 2013; unpublished and local demography reports e.g., Lesmeister et al. 2019 for historic occupancy).

The Service recognizes that many different combinations of forest habitat structure and amount at various spatial scales may support viable spotted owl territories sufficient for the survival and reproduction of individual owls. Despite consistent patterns of habitat selection by spotted owls, structural conditions of forest habitats occupied by spotted owls are highly variable. However, overall, the best available information suggests that: (1) the probability of spotted owls occupying a given patch of forest habitat is increased when core areas contain a range of forest habitat conditions that support the essential life history requirements of individual spotted owls; and (2) the survival and fitness of spotted owls are positively correlated with larger patch sizes of older forest or larger patches of forest habitat with a high proportion of older forest (Franklin et al. 2000, Olson et al. 2005 and Dugger et al. 2005).

**Dispersal Habitat**

Dispersing spotted owls are essential to maintaining stable populations by filling territorial vacancies when resident spotted owls die or leave their territories (colonization phase), and to providing adequate gene flow across the range of the species (transience phase). The effects analysis for owl dispersal habitat considerations is informed not only at the stand level (as discussed in the Definitions section above) but also and more importantly by landscape conditions, as suggested by Thomas et al. (1990) along with Lint et al. (2005) and Davis et al. (2016). Typical dispersal-only habitat is characterized as forest stands less than 80 years old, of simple structure, and providing some foraging structure and prey base for owls as they disperse across the landscape (Miller et al. 1997 and Courtney et al. 2004) with adequate tree size and canopy to provide protection from avian predators (USDI FWS 2011b). However, dispersal

habitat not only includes the forests as previously described but also forests greater than 80 years old which provides better dispersal conditions due to stand structure and available prey (Miller et al. 1997, Courtney et al. 2004 and Sovern et al. 2015). Although, as Buchanan (2004, p.1341) noted, the stand- and landscape-level attributes of forests needed to facilitate successful dispersal may not have been thoroughly evaluated. An assessment of dispersal habitat condition was recommended on the quarter-township scale by Thomas et al. (1990); the U.S. Fish and Wildlife Service has subsequently used fifth-field watersheds or larger landscapes for assessing dispersal habitat conditions because watersheds or provinces offer a more biological meaningful way to conduct the analysis (see Davis et al. 2011). Forsman et al. (2002, p. 22) found that spotted owls could disperse through highly fragmented forest landscapes. To assess potential impacts in the ability of spotted owls to move across a given landscape, Davis and others (2016, p.12) recently described "dispersal-capable landscapes" as those which contain ≥40 percent dispersal-quality habitat.

**Role of Forest Canopy in Spotted Owl Habitat Selection**

Because the terms canopy cover and canopy closure are often used inter-changeably in the literature and among resource professionals despite technically being considered different measurements (Jennings et al. 1999, entire), we believe it important to make the distinction that in this opinion, and which may not be applicable for other biological opinions or elsewhere in the range of the spotted owl, the Service and the District are using canopy cover to characterize pre- and post- treatment characterization of spotted owl habitat. Characterizing canopy by using "cover" has relied on the Rogue Basin Level 1 Team's determination of the best available science for each consultation, as appropriate.

There is little dispute in the literature that canopy cover or closure is just one of several indicators in estimating the likelihood of use of a stand by a spotted owls and that relatively high canopy cover or closure correlates with presence and use by spotted owls. However, inconsistent methodology and estimation methods do not necessarily lend themselves to a definitive standard for use of an area by spotted owls.

The Service uses current and expected residual canopy as one factor in its evaluation of potential impacts to spotted owls. Canopy is believed to be important to spotted owls because of prey associations (Forsman et al. 1984, pp. 55-56), acting as a thermal mediator (Forsman et al. 1984, pp.29-30, Barrows 1981 and Thomas et al. 1990, pp.171 and 278) and providing concealment cover for predator protection (Thomas et al. 1990, pp. 299-300). Canopy alone is unlikely to provide good insight into a stands ability to provide spotted owl habitat; rather, it is one of the factors associated with use. For example, lower quantities of one factor may be ameliorated by higher quantities of other; North et al. (2017) found canopy cover of large trees a better predictor of California spotted owl nest site locations than total canopy cover. Most likely, it is the combination of several factors in variable quantities that influence the likelihood of spotted owl use (Zabel et al. 2003, Irwin et al. 2007). Generally, however; there is little evidence that stands with <40 percent canopy cover are substantially used by owls, and that 40 to 60 percent canopy may not preclude use if other features are present (e.g. perches and relatively higher prey density), while stands with denser canopy cover are most commonly used by spotted owls for nesting and roosting. Habitat structure and composition are described in detail in the final rule

Revised Critical Habitat for the Northern Spotted Owl (USDI FWS 2012). NR habitat function evaluation has to take *all* of the fundamental elements into consideration, and none should be considered in isolation.

## EFFECTS OF THE PROPOSED ACTION

Effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (USDI FWS and USDOC NOAA 2019).

The effects analysis below assumes full implementation of the PDCs (see above and Appendix B) included as part of BLM's proposed action.

### Overview

We evaluate potential impacts to NRF habitat in the context of the scope and intensity of proposed treatments, the treatment location and distribution, and how these factors may influence the life functions of spotted owls and their prey. Specific terms are used herein to categorize the estimated degree of change (potential effect) to spotted owl habitat elements that may or are likely to be caused by the proposed action. For example, the term *downgrade* signifies that the proposed treatments may have a negative influence on the quality of affected spotted owl habitat by removing or reducing habitat elements that support spotted owl life history requirements. The term *remove* pertains to treatments that significantly reduce or remove the elements of habitat to the degree that it no longer supports spotted owl life history requirements. The term *modify* is the treatment defined when an action or activity in nesting-roosting, foraging, or dispersal-only habitat removes some trees or reduces the availability of other habitat components, but does not change the current function of the habitat because the conditions that would classify the stand as NR, F, or dispersal-only habitat would remain post-treatment (see Definitions, p. 6)

Determination of the significance of changes to spotted owl habitat likely to be caused by proposed activities, and whether these changes are likely to adversely affect spotted owls or their critical habitat, must also be based on an analysis of site-specific conditions, type of treatment(s), and the scale of dependent factors (e.g., nesting, foraging, or dispersal). Spotted owl responses to changes of nesting and roosting habitat via mechanical treatments are likely most influenced by relative changes in important structural features such as canopy, availability of dense clumps of larger trees, and nesting structures such as mistletoe brooms, tree cavities, and large snags. The removal of trees with defects and snags that could serve as nesting structures may reduce nesting opportunities for spotted owls and the simplification of canopy layering can degrade the thermal and protective properties found in multi-storied stands.

We also evaluate the Project's potential impacts to spotted owls and their habitats in context with the threats to, and trends of habitat observed in available information. Over the last two decades, the rates of habitat loss from high severity fires have disproportionately affected Oregon and

California Klamath Physiographic Provinces (particularly reserves) and to some extent the Oregon West Cascades province. These losses correspond with areas intended for long-term conservation (reserves) (Davis et al., 2011, p. iii; Davis et al. 2016, page 23, 35-38) as well as within a portion of the range noted as important for spotted owl recovery and conservation (Schumaker et al. 2014, pp. 587-588). Recent studies and reviews of existing literature shows the current condition and trends of western forests and the restoration approaches for achieving more historical variation (Hessburg et al. 2015, Haugo et al. 2015, Willms et al. 2017). In southwest Oregon specifically, about 50 percent of the forests were identified as needing some form of disturbance in order to retain the natural range of variability of forest structure (Haugo et al. 2015, Table 5, p. 47). To address the low diversity of current stand conditions typical in many areas of western states, management recommendations proposed by these reviews include a range of treatment types, some similar to the Proposed Action. Variable approaches within each are dictated by many factors including objectives for specific landscapes, but recommended treatments included mechanical commercial and non-commercial thinning, prescribed burning, managed wildfire, and prevention so as to improve stand resiliency (Haugo et al. 2015, pp. 46-48; Hessburg 2016, entire; Willms 2017 pp. 187-188).

In forests characterized by mixed severity fires, restoration-based treatment objectives that promote larger patches of older, larger, widely-spaced trees with variable understories, in addition to fine-and large scale heterogeneity will increase landscape resistance to severe fires (as reviewed in Hessburg et al. 2016, pp. 233-234) (see text below). Resiliency-based treatments can variably influence the occurrence and/or richness of shrubs or herbaceous vegetation depending on the treatments or combination of treatments (Fulé et al., 2005, Willms et al. 2017, pp. 191-192). As a consequence, variable direct and indirect effects to prey may result from these treatments (see *Impacts to Prey*). In a meta-analysis of biodiversity response to biomass treatments, Verschuyl et al. (2011, p. 227) found forest thinning treatments had generally positive or neutral effects on diversity and abundance across all taxa but that the degree of impact to species depended upon the intensity and the type of thinning conducted.

Forest-habitat management decisions sometimes face competing opinions, incomplete information and some degree of uncertainty. This is sometimes the case in conducting treatments for forest restoration and resiliency projects, such as covered in this Opinion. The Service's Revised Northern Spotted Owl Recovery Plan (USDI FWS 2011) reviewed the best available information, weighed the uncertainty and provided restoration principles and discretionary recovery actions to address the threat from habitat loss due to large-scale wildfire in the dry forest ecosystems. However, in areas where land managers are considering competing land management goals (e.g., northern spotted owl habitat conservation vs. commercial timber harvest), the Service encourages managers to consider an ecological forestry approach to better meet the needs of the northern spotted owl, the goals of the land managers, and long-term forest health.

**Effects to Habitat**

The District's FY20 Batch of Projects have been designed consistent with the BLM's Southwest Oregon RMP (USDI BLM 2016a) by following management directions for each of LUAs within the Bear Grub and Round Oak Action Areas. Collectively for both areas, this consists of 69 percent of the proposed treatments located within the HLB (MITA, LITA and UTA) (5,640 acres) and the remaining treated acres proposed within District Designated Reserve (1,371 acres), LSR (451 acres), and Riparian Reserve (680 acres) LUAs (Table 2).

Collectively, up to 8,142 acres of forest-related treatment projects are proposed (Table 2) and consist of up to 2,131 acres of early-seral habitat (Capable) and Non-habitat (Assessment, p. 11). These areas currently do not contain stand conditions providing for spotted owl habitat and providing for relatively little use, therefore Capable and Non-habitat areas affected by the proposed action will not be analyzed further in this analysis with the exception that effects of the action on capable habitat will be analyzed as part of the assessment of effects to spotted owl Critical Habitat. Up to 2,011 treatment acres are within dispersal-only habitat and 58 percent of these acres will have *modify* harvest prescriptions (Table 12), meaning that these stands post-treatment, are expected to retain dispersal function. Approximately 4,000 acres of spotted owl NRF habitat is proposed for treatment with 23 percent of these acres (~ 920 acres) having *modify* prescriptions (Table 12). NRF removal and downgrades accounts for 38 percent of the overall proposed action and approximately 77 (~ 3,080 acres) percent of the proposed NRF treatments (Table 12).

As noted above, as has been demonstrated based on previous projects, it is likely the effects to habitat caused by the proposed action could be reduced at the time and temporally implemented over multiple years because NEPA decisions may reduce treatment acres and/or economic or logging feasibility issues may occur, resulting in fewer acres offered for sale (Assessment, p. 37); however, for the purposes of this analysis of effects, the acres affected are included herein (Table 12). Annual consultation monitoring reports (Appendix C) will reflect the actual acres affected by the proposed action and will be used to adjust the habitat baseline, as appropriate.

**Table 12. Summary of Effects to Spotted Owl Habitat from the Bear Grub and Round Oak Projects, Medford District BLM.**

| | NRF Remove (acres) | | NRF Downgrade (acres) | | NRF Modify (acres) | | Dispersal-only Remove[3] (acres) | Dispersal-only Modify (acres) | Dispersal Quality Remove *(NRF+Dispersal-only)[4]* | Total Habitat Acres Treated[5] |
|---|---|---|---|---|---|---|---|---|---|---|
| | NR[1] | F[2] | NR[1] | F[2] | NR[1] | F[2] | | | | |
| ***Bear Grub Action Area Baseline Habitat** (From Table 5)* | *(17,669)* | | | | | | *(20,114)* *(Dispersal-only)* | | *(37,783)* *(NRF + Dispersal-only)* | *78,028[1]* *(total AA)* |
| **Bear Grub** | 96 | 599 | 2 | 57 | 37 | 550 | 599 | 976 | 1,294 | 2,916 |
| **% Change to the Bear Grub Action Area Baseline Habitat** | -3.4% | | -0.3 | | No Change | | -3% | No Change | -3.4% | 3.7 % of AA treated |
| ***Round Oak Action Area Baseline Habitat** (From Table 6)* | *(13,807)* | | | | | | *(24,121)* *(Dispersal-only)* | | *(37,928)* *(NRF + Dispersal-only)* | *57,737[1]* *(total AA)* |
| **Round Oak** | 1,068 | 1,278 | 0 | 0 | 85 | 234 | 279 | 190 | 2,625 | 3,134 |
| **% Change to the Round Oak Action Area Baseline Habitat** | - 17 % | | No Change | | No Change | | -1.2% | No Change | -6.9% | 5.4 % of AA treated |
| **TOTAL HABITAT EFFECTS FOR the FY20 BATCH BA** | 1,164 | 1,877 | 2 | 57 | 122 | 784 | 878 | 1,166 | 3,919 | 6,050 |

1-NR = Nesting/Roosting; 2 - F = Foraging; 3 - Baseline is Dispersal-Only habitat; 4- Baseline is Total Dispersal Quality Habitat (NR and F + Dispersal-Only Habitat);5 - Total Action Area acres across all ownership, including non-habitat and capable habitat acres

Effects to NRF habitat in the LSR LUA include approximately 5 acres of removal due to road and landing construction (Bear Grub=2, Round Oak = 3), 53 acres of NRF downgrade (Bear Grub = 53 and Round Oak = 0 acres) and 86 acre of NRF modify treatments (Bear Grub = 86 and Round Oak = 0 acres). As described in the SW OR RMP/ROD (p. 70 and 71), removal and downgrade of NRF habitat is consistent with the RMP for certain types of projects. Specific to the 53 acres of NRF downgrade, the objectives here including reducing stand densities now so as to set the stand on a more desirable stand development trajectory to create a multiple canopy, multi-age stand for the future. These treatments would accelerate the development of forest stand conditions for northern spotted owl habitat and shift stand trajectories to encourage key habitat components for the future. Conversely, stands in which treatments are not applied would maintain a higher relative density and would remain in a homogenous and uniform stand structure of less complexity until a natural disturbance event takes place. For likely outcomes of the treatments, please see the Bear Grub Vegetation Management Project Environmental Assessment (pp. 24-32 and 76).

All acres of NRF modify treatments (86 acres) in the LSR LUA are for hazardous fuels reduction; these treatments are consistent with the Management Direction of the RMP.

## Effects to NRF Habitat from NRF Removal and Downgrade

Under the proposed action, the District's objectives for NRF removal (Table 12) are primarily intended to contribute to the ASQ. Proposed activities (i.e., *commercial thinning, regeneration harvest, restoration thinning, selection harvest, integrated vegetation management, road and landing construction*) would remove large trees that could serve as spotted owl nest structure,

reduce the overall average canopy cover within the affected stand to near or below approximately 40 percent, diminish the existing multi-canopy (layers), and other key habitat features, rendering the affected stands non-functional as spotted owl nesting habitat. These treatments, primarily large tree removal, are expected to result in mostly unusable NRF habitat within the affected stands for decades post-treatment.

Downgraded habitat however, can still provide dispersal function due to remaining canopy, perches and food resources and in some cases function as foraging habitat depending on the site-specific conditions. For example, if the post-treatment conditions of the stands are variably open due to having skip areas with dense pockets of trees, remnant large trees and mixed sized hardwoods, which is an expected situation with some of the downgraded stands, best available information shows spotted owl with some frequency, make use of these treated stands (see Zabel et al. 1992a and b). Further, there is some potential for short-term foraging opportunities in harvested areas (Sisco 1990, Folliard 1993 and Irwin et al. 2012) (including in NRF removal areas) if the harvested areas are connected or adjacent to higher quality habitat or smaller order watercourses (Irwin et al. 2011, pp. 9-10). So while there may be negative impacts from the proposed action (i.e., removal and downgrade) to NR and F habitats, depending on site-specific situations, spotted owl may not totally avoid harvested areas post-treatment. Downgrade treatments in Bear Grub are intended to develop NR habitat in LSR, and there are no downgrade treatments in Round Oak.

Due to NRF removal and downgrade, the habitat-fitness of any affected spotted owls to reproduce and survive is likely to be reduced, albeit depending on unit proximity to nest site locations. Because incidental take of spotted owls is to be avoided under this consultation, only the unoccupied spotted owl sites will be subject to the associated demographic impacts. These sites however, may become unavailable to spotted owls for decades.

As provided above, 1,081 acres of the NRF removal and downgrade is proposed in HLB LUA. This LUA is the portion of the landscape not being relied upon for supporting reproducing populations of spotted owls and where BLM is targeting timber removal at unoccupied sites (per Recovery Action 10, as described below in the Recovery section) and not where recovery of the spotted owl will be focused. Future development of spotted owl habitat and management of barred owls in the LSR LUA is expected to provide for territories that will support future spotted owl populations (USDI FWS 2016 p. 583).

For the aforementioned reasons, NRF habitat removal and downgrade activities from Bear Grub and Round Oak are likely to have *adverse effects* to spotted owl NRF habitat. However, as per Table 12, most of the NRF habitat in the action areas will not be impacted by the proposed action. Substantial removal of spotted owl habitat in the HLB LUA under the RMP was expected and analyzed. The spatial configuration of reserves, the management of those reserves to retain, promote and develop spotted owl habitat, the management of the HLB and the scheduling of the management of the HLB are expected to provide for spotted owl dispersal between physiographic provinces/modeling regions and between and among large blocks of spotted owl habitat designed to support clusters of reproducing spotted owls (USDI FWS 2016 pp. 637-638). Overall, under the duration of the RMP an overall net positive conservation outcome at the landscape scale of the plan and to improve habitat conditions for the spotted owl

in the LSRs is expected (see Late-successional reserve section below). Therefore, the Service did not expect timber harvest during the interim (take avoidance) period to influence the distribution of spotted owls at the local, action area or range-wide scales.

**Effects to NRF and Dispersal-only Habitat due to Modify Prescriptions**

The objectives of *modify* treatments (i.e., *riparian thinning, selection harvest, pre-commercial thinning, density management, yarding corridor only areas, and hazardous fuels maintenance*) in NRF (906 acres) and dispersal-only (1,166 acres) habitats are to contribute to the District's ASQ, and, in some cases, to improve forest-stand resiliency by reducing tree competition for resources in stands with high relative tree densities (Table 12). To achieve the outcome of retaining stand-habitat function post-treatment, the District will adhere to the PDCs (see Assessment, pp. 20-24 and above in the PDC section). In general, "modify" treatments are not anticipated to result in adverse effects because the habitat is expected to retain a similar habitat function post-treatment as pre-treatment.

Up to 757 acres of *modify* treatments are planned for the HLB and 169 acres in the LSR (acre values per personal communication R. Snider July 2020). For the LSR, the modify acres, as per RMP Management Direction and Objectives for LSR treatments are to reduce the risk of wildfire through fuels treatments. The proposed action is expected to attain the RMP-LSR management objectives.

**Effects due to Removal of Spotted Owl Dispersal-quality Habitat (NRF and Dispersal-only) and nonterritorial spotted owl considerations**

The proposed action includes the removal of approximately 1,294 acres for Bear Grub and 2,625 acres for Round Oak (Tables 12 and 13) of dispersal-only quality habitat, resulting from commercial thinning, regeneration harvest, selection harvest, integrated vegetation management, restoration thinning, riparian commercial thinning, road and landing construction. An evaluation of effects to spotted owl dispersal includes both stand- and landscape-level considerations. While stand level effects are considered, the effectiveness of spotted owl dispersal is most meaningfully evaluated at a landscape scale (see Thomas et al. 1990, Lint 2005 and Davis et al. 2016; however see Buchanan 2004 [USDI FWS 2016]). Analysis of movement data of spotted owls suggest that most (90 percent) of dispersal occurred through landscapes meeting criteria of having > 11 inch dbh trees and 40 percent canopy cover (at the stand level) capable of supporting dispersal (Davis et al. 2011 and 2016, Forsman et al. 2002 and Lint 2005). However, these findings remain untested but this approach represents best available information for analyses. Only two studies (Miller et al. 1997, Sovern et al. 2015) have empirically studied forest-type selection during juvenile dispersal. Both studies found that juveniles select for old forest with closed canopy (>70 percent canopy cover) and large-diameter trees (>20 inch d.b.h.), which are similar forest conditions selected by adult spotted owls for nesting and roosting (Miller et al. 1997, Sovern et al. 2015). Miller et al. (1997, p. 145) also found that dispersing spotted owls selected for closed-sapling-pole saw timber stands. In general, dispersing spotted owls tend not to select and/or avoid more open forest conditions (Miller et al. 1997). The stand level descriptions in these studies are similar to the dispersal-quality habitat analyzed herein.

Fragmented forest landscapes are more likely to be used by spotted owls in the transience phase as a means to move rapidly between denser forest areas (Courtney et al. 2004, pp. 5-13; USDI FWS 2012 p. 71875). Movements through closed canopy forests occur during the colonization phase when birds are looking to become established in an area (Miller et al. 1997, p. 144; Courtney et al. 2004, pp. 5-13). Transient dispersers use a wider variety of forest conditions for movements than colonizing dispersers, who require habitats resembling NRF habitats used by breeding birds (USDI FWS p. 71875).

Landscapes with 40 to 50 percent (or more) dispersal-quality habitat are more likely to provide habitat connectivity conducive to spotted owl dispersal (Davis et al. 2016). For purposes of this analysis, landscapes, such as fifth-field watersheds and the overall habitat condition of the action area, are useful scales to evaluate the project's effects on dispersal habitat connectivity and represent best available information.

The proposed action is expected to remove dispersal-quality habitat from seven of the eight fifth-field watersheds associated with the action areas. However, the post-watershed condition per habitat removal is not anticipated to meaningfully impact the overall dispersal-habitat condition because there will be less than a 1 percent change per watershed. As such, each watershed will have at least 40 percent dispersal-quality habitat remaining, post project (Table 13) and likely sufficient for landscape-habitat connectivity based on best available information. It should be noted that the Bear Grub watershed will have approximately 40 percent habitat, post treatment.

Forest landscapes traversed by dispersing owls typically include a fragmented mosaic of roads, clear-cuts, and non-forested areas, and a variety of forest age classes ranging from fragmented forests on cutover areas to old-growth forests (Forsman, et al. 2002). Miller et al. (1997, p. 147) found that dispersing juvenile owls selected equally between less fragmented and more fragmented forests. Although, while difficult to quantify the relationship between forest fragmentation and dispersal, Miller et al. (1997) noted that indirect evidence suggests that fragmentation may require owls to disperse greater distances to locate preferred habitat, and also that owls that confront clearcuts while dispersing in fragmented forests may actually reduce their dispersal distances. There will be some areas of concentrated treatment, but these areas are not expected to preclude dispersal. Also, Bear Grub watershed has existing conditions of large open, valleys and rural residential areas. While there will be a reduction in dispersal habitat, we do not expect dispersal to be precluded in this already fragmented situation. As a result, large blocks/areas of non-habitat (open areas) are not expected to be created by the proposed action and result in barriers to dispersal.

According to BLM, no large-scale fires of significance overlap the Bear Grub and Round Oak action areas, with the exception of the Squires Peak fire in 2002 (see Assessment); the environmental baseline and analysis herein reflects the changes. However, there have been notable changes, including the Biscuit and more recent Chetco, Klondike, Miles, Taylor Creek, Evans Creek, Big Windy, Douglas Complex and Mile Post 97 fires that have likely created challenges to dispersal-habitat landscape condition across greater southwest Oregon. Prior to the 2018 fires, Davis et al. (2016 p. 28 and Figure 9 p. 33) concluded that the large reserve network in this portion of the spotted owl's range in southwest Oregon remains mostly intact for dispersal. With foresight, the LSRs under the NWFP within the fire-prone provinces were

designed with wildfire in mind. LSRs were delineated to be large enough to withstand large wildfire events over 50 years such that unburned portions would maintain a well-connected network of dispersal-quality habitat (USDA and USDI 1994, apps. J3-8 and 9). As mentioned elsewhere herein, the BLM is providing protection to additional acres of NRF habitat, over previous BLM plans, which were part of the NWFP. The additional habitat protection afforded under the revised RMP provides for continued redundancy of LSR protection and support to dispersal capable landscapes. However, given the increased frequency of large wildfires, and the disproportionate impact of fires in the large reserves in southwest Oregon, this design feature may be challenged in the near future.

In the Service's Opinion on the RMP, the Service concluded that the spatial configuration of reserves, the management of those reserves to retain, promote and develop spotted owl habitat, the management of the HLB and the scheduling of the management of the HLB are expected to provide for spotted owl dispersal between physiographic provinces/modeling regions and between and among large blocks of spotted owl habitat designed to support clusters of reproducing spotted owls. Therefore, the Service did not expect timber harvest during the interim (take avoidance) period to influence the distribution of spotted owls at the local, action area or range-wide scales.

Due to the dispersal-quality habitat conditions in the watershed, post-treatment above 40 percent of the watershed in closed canopy condition, and more BLM lands in reserved status, we conclude the Bear Grub and Round Oak action areas are likely to continue to support functional dispersal habitat/connectivity and colonization for spotted owls.

**Table 13. Pre and Post-Project Dispersal Conditions in the Fifth Field Watersheds from the Bear Grub and Round Oak Proposed Actions, Medford District BLM.**

| 5th Field Watershed *(Project)* | Total Watershed Acres | Total Dispersal Acres (NRF+ Dispersal Only) Pre-treatment | % Watershed Dispersal Habitat (NRF +Dispersal-only) Pre-treatment | Total NRF Removed | Total Dispersal -only Removed | % Watershed Dispersal (NRF+DO) Habitat Post-Treatment | Total % Reduction from Proposed Action |
|---|---|---|---|---|---|---|---|
| **Bear Creek (Bear Grub)** | 231,067 | 93,912 | 40.6 % | 229 | 76 | 40.5 % | -0.1 % |
| **Big Butte Creek (Round Oak)** | 158,137 | 106,197 | 67 % | 1,096 | 57 | 66 % | - 1 % |
| **Little Applegate River (Bear Grub)** | 72,245 | 42,567 | 59 % | 133 | 261 | 58 % | - 1 % |
| **Middle Applegate River (Bear Grub)** | 82,537 | 43,725 | 53 % | 330 | 259 | 52 % | - 1 % |
| **South Fork Rogue River (Round Oak)** | 160,657 | 122,041 | 76 % | 1,251 | 222 | 75 % | - 1 % |

*Effects to Non-breeding "floater" spotted owls*

Northern spotted owl populations consist of the territorial, resident owls, for which we have documentated occupancy throughout much of the owl's range, but also include nonterritorial (non-breeding) adult ''floaters'' spotted owls. Nonterritorial spotted owls are present on the landscape and use closed canopy forest habitat to support transient and colonization phases until they recruit into the breeding population. However, nonterritorial spotted owls are difficult to detect in surveys because many floaters either do not respond to surveys or respond in very tenuous fashion such that they are difficult to capture or resight (Forsman et al. 2002, p. 26).

Nonterritorial spotted owls generally persist in the population and use a series of temporary home ranges to systematically sample or "prospect" the underliying network of resident territories along a somewhat erratic dispersal path (Forsman et al. 2002, p. 30). Because they are difficult to detect, the number and distribution of nonterritorial and dispersing spotted owls are poorly known for any given northern spotted owl population. Male and female nonterritorial spotted owls are recruited into the population differently through recruitment and immigration (Franklin 1992, p. 822). Nonterritorial spotted owls likely contribute an important role is spotted owl population regulation. However, for monitored populations, population change was more sensitive to adult survival than to recruitment (Glenn et al. 2010). Also, the rate of population change in spotted owls is most sensitive to variation in adult female survival and relatively insensitive to variation in fecundity and age at first reproduction (Noon and Biles 1990). As such, the degree to which floaters influence or regulate populations is unknown, for example in Franklin's study population (Franklin 1992).

The distribution of closed canopy forest relative to the spotted owl's ability to locate and that are accessible affect the persistence of the spotted owl population. In the Bear Grub and Round Oak action areas, much of these areas are covered by the 43 spotted owl home ranges. As much as 96 and 83 percent NRF habitat in the Bear Grub and Round Oak action areas will not be impacted by the proposed action. And therefore, nonbreeding spotted owls should be able to access some of this habitat, albeit depending on competition from territorial spotted owls and interference competition from barred owls. There is also over 3,000 acres of available habitat outside of home ranges in the actions areas, with over l,000 acres being surveyed due to proposed nearby projects. To date, surveys are not detecting resident spotted owls (i.e, colonizing spotted owls). Because spotted owl populations are regulated by territorial behavior, declines in the territorial component initially would be dampened by the increased recruitment of floaters. If the number of floaters is sizable, then the number of territory holders would appear stable for some time before a decline is observed. With the barred owl impact reducing spotted owl populations and demographic rates and the overall lack of occupied territories on the Bear Grub and Round Oak action areas, it is likely the floater population has decreased and thus not replacing the territory holders. Given the lack of territory occupancy, these acres should be accessible to nonbreeding spotted owls to be colonize as territory holders.

Conservation of closed canopy forest under the BLM's RMP Reserves, whether LSR, DDR or RR, provides for patches of habitat to be occupied by breeding adults and provide colonization areas for subadults during the years before their recruitment into the breeding population. Habitat in Reserves (LSR, DDR, RR) will provide potential travel corridors for both

juvenile and displaced adult owls during transient dispersal. Given the increased propensity for inter-territory movements by adult resident spotted owls because of barred owls, habitat in the Reserves along with HLB habitat not impacted in the action area, is likely to provide habitat for temporary home ranges for spotted owl currently in – or that will enter- the nonbreeding population.

As mentioned above, because they are difficult to detect, the number and distribution of nonterritorial spotted owls is poorly known for any given spotted owl population. In evaluating conservation scenarios under the spotted owl recovery plan and the revised BLM RMPs, spotted owl population modeling was conducted (see USDI FWS 2011 – Appendix C, USDI BLM 2016 and Dunk et al. 2019). In the modeling scenarios, nonbreeding spotted owls were simulated and incorporated into HexSim population modeling. The results showed that additional protection of habitat on the landscape does not necessarily improve the situation for spotted owls, while barred owls are on the landscape, unless barred owls are reduced. With the population analysis, incorporating nonterritorial spotted owls, and the anticipated spotted owl response, with barred owls on the landscape, the Service's opinion of No Jeopardy on the BLM's RMP relied on: 1) No incidental take of spotted owls to minimize effects to spotted owl survival for an interim period and; 2) Sufficient area and distribution of forested area reserved from sustained yield harvest to protect the majority of existing habitat and allow development of additional habitat to support population persistence and expansion.

## EFFECTS TO SPOTTED OWLS

For the purposes of this analysis, changes in habitat conditions caused by the proposed action within 1.3 miles in the Klamath Mountains Province and 1.2 miles in the West Cascades Province of a project footprint will be analyzed to determine the effects on spotted owls, and reflects best available information (see the *Spotted Owl Resource Use* section above). As described above and in the Assessment, the District utilized multiple sources of habitat data to inform their characterization of spotted owl habitat within the project footprint and to inform the characterization of baseline spotted owl habitat conditions at the action area scale and is considered the best available information.

The potential impacts to spotted owls presented below relies on the scope and intensity of the proposed habitat treatments, the treatment location and distribution relative to known spotted owl sites, and how these factors may influence the capability of spotted owls and their prey to survive and reproduce.

### *Amount of Habitat Available*

Bart (1995) reported a linear reduction in spotted owl productivity and survivorship as the amount of suitable (NRF) habitat within a spotted owl home range declined. Many researchers have stressed the importance of habitat availability within a core area around the nest site (Bingham and Noon 1997; Franklin et al. 2000; Hunter 1994; Meyer et al. 1998; Zabel et al. 2003). However, in some situations, spotted owls have been shown to successfully reproduce with a minimum of 20 percent NRF habitat in the core area around the nest site (Bart and Forsman 1992). The proposed action minimizes effects to spotted owls by directing harvest, to

the extent practicable, within unoccupied spotted owl home ranges, and/or occupied sites with maintain prescriptions and/or home ranges with habitat quality and quantity at sufficient levels per best available information (see Recovery Action 10 discussion below). Because incidental take is to be avoided, only the unoccupied spotted owl sites will be subject to these impacts; however, these sites may become unavailable to spotted owls for decades in the HLB. Harvest activities in the HLB are primarily to meet ASQ objectives with secondary objectives of creating more fire resilient conditions of the treated stands with likely some benefits of reduced fire risk to adjacent NRF stands. The HLB LUA is not where recovery of the spotted owl will is focused and is not being relied upon for supporting reproducing spotted owls. Future development of spotted owl habitat and management of barred owls in the LSR LUA is expected to provide for territories that will support future spotted owl populations (USDI FWS 2016 p. 583).

***Thinning-Removal Intensity***

The intensity of mechanical treatment influences the degree of change to habitat suitability. For example, heavier treatments in NRF habitat, such as removal have a higher likelihood of negatively affecting spotted owls due to the reductions in cover and structural complexity. Spatial distribution of treatments can also influence habitat use, whereby large openings will create areas that are less unusable by spotted owls until the forest recovers; however edges of these openings may be used to opportunistically access prey such as woodrats that may occupy the shrub habitats or early successional conifer vegetation. The thinning prescriptions proposed under the “modify” treatment are designed to retain key habitat elements (e.g., canopy, basal area, layers, etc.) and habitat functionality. For example, within stand vegetation layers are considered important characteristics of spotted owl habitat (Anthony and Wagner 1998, Mills et al. 1993 and North et al. 1999). In many cases, there will be immediate improvements in stand structure from the proposed treatments that reduce the dense or uniform pole-sized Douglas-firs and create variable understories that spotted owls can navigate through. However, there is some uncertainty regarding the response of the spotted owls to these types of treatments (see Habitat with Modify Prescriptions below), especially at the scale proposed, along with the combined or additive effect of the presence of barred owls in this landscape. Additionally, there are varying effects to prey depending on pre-existing treatment stand conditions, adjacent stand conditions, and prey species’ ecology.

***Affected Habitat***

Spotted owls depend on multi-storied, structurally complex forests that are dominated by large trees, and high densities of down and standing coarse wood. Habitats that contain these attributes are considered to be high quality NRF habitat for spotted owls. The reduction of the amount of NRF habitat, or large proportions of habitat within home ranges, especially close to the nest site, can be expected to have negative effects on spotted owls. For example, habitat changes within core-use areas could have disproportionate effects to individual spotted owls. Demographic parameters have been positively related to the proportion of these older forests and the amounts of edge of other vegetation types (Bart 1995; Franklin et al., 2000; Olson et al. 2004; Dugger et al., 2005; and others). The higher the proportion of affected high quality habitats, the more severe the potential effects may be. The most pronounced and impactful effects to spotted owl habitat will be through the approximately 3,100 acres (3,041 acres NRF

removed and 59 acres NRF downgraded) of NRF habitat removal and downgrading (Table 12). While these treatments are spatially and temporally distributed across the District in the two large action areas, the treatments are likely not insignificant and discountable.

***Abiotic Factors***

In addition to forest structure, some landscape factors act to influence the habitat value of forest stands for spotted owls in the mixed-conifer hardwood forests. Spotted owl foraging is strongly associated with distance to streams, proximity to nest sites, slope position, aspect, and elevation (Irwin et al. 2007, pp. 1187-1188; USDI FWS 2009, p. 58; Irwin et al. 2011, p. 208-209). We consider the treatments locations relative to known sites but also relative to areas of likely use.

***Proximity to the Nest Area***

Because of their central-place foraging tendency (Rosenberg and McKelvey 1999, entire), thinning close to a nest area has a higher likelihood of negatively affecting spotted owls than does thinning further from a nest area (see Meiman et al. 2003 and Forsman et al. 1984). Of the 43 sites within the action area, there are 12 sites with proposed treatments in the nest patch. These treatments range from removal (2-64 acres) to thinning *but* do not occur within occupied sites.

***Affected Home Ranges***

There are 43 spotted owl sites/territories affected by the FY20 Batch of Projects because the proposed action are within these home ranges (Table 15). Based on the intensity, location and spatial relationships of the proposed treatments within the 43 spotted owl home ranges, the Level 1 Team has determined that adverse effects are likely to occur to spotted owls at 37 sites (Table 15). The adverse effects are primarily due to the removal and downgrade of NRF habitat within core-use and/or home ranges (Table 16). Many of the sites under the proposed action are currently in habitat limited situations (Table 16), based on best available information and further reductions in NRF habitat are likely to have negative effects on spotted owl demographic parameters. For example, best available information suggests that when less than 40 to 60 percent of the home range is NRF habitat, the likelihood of spotted owl presence is lower and survival and reproduction may be reduced (Thomas, et al. 1990; Bart and Forsman 1992; Bart 1995; Dugger, et al. 2005). These central tendency values, along with site-specific conditions and spotted owl occupancy inform a determination of harm; which is provided below.

In addition to the 43 site/home ranges mentioned above, there are 16 spotted owl site centers outside of the action areas with a portion of their home range overlapping the action areas. However, no treatments are proposed within these home ranges. The District has determined that the proposed action will not affect spotted owls at these 16 sites.

It should be noted that spotted owl home ranges represent the movement patterns for resident spotted owls, as such, spotted owls are unlikely to use project areas outside of their home ranges (see Resource Selection section above). As stated above, both action areas have more than 80 percent NRF habitat not impacted by the proposed action, dispersal-habitat-connectivity is

expected to provide continued function and prey resources are likely to be available and accessible post-project.

**Table 14. Bear Grub and Round Oak Spotted Owl Site Effects Table Summary (from Assessment Appendix C, Table C-1), for the FY20 Batch of Projects, Medford District BLM.**

| | LAA Sites | NLAA Sites |
|---|---|---|
| Bear Grub | 23 | 2 |
| | 0096O, 0097O, 0114O, 0592O,0944O, 0971O, 0972O, 0973A, 0992O, 2234O, 2260B, 2267O, 2361O, 2394O, 2397O, 3648O, 3934O, 3941O, 3942O, 4066O 4068O, 4513O, 4611O | 2395O, 3559O |
| Round Oak | 14 | 4 |
| | 1163O, 1826B, 1831A/1831O, 1957B/1957F, 1958A, 2059A/ 2059O, 2359O, 2360A, 3260O, 4079O, 4616O, 4620O, FS-DD, FS-OM | 2007B, 2220O, 2222A/2222O,3561B |
| TOTAL | 37 | 6 |

***Alternate Habitat Available***

Availability of alternative untreated habitat can reduce the likelihood that treatments can negatively affect owls. The majority of NRF habitat in the action areas, 96 percent in Bear Grub and 83 percent in Round Oak, will remain untreated under this consultation (Assessment, pp. 26-27 and Table 12 herein). For treated NRF habitat, approximately 1,018 acres are outside of spotted owl home ranges (Assessment Table 17) which represent 25 percent of the total NRF acres proposed for treatment.

Barred owls are documented in the action areas (Table 10) and further analysis of barred owl-spotted owl competition and available habitat, please see section below.

***Spotted Owls Likely to be Adversely Affected from the Proposed Action:***

Based on a site by site analysis along with the effects descriptions provided in the Definitions section above and the acres of effects provided in the Effects to Habitat section above, spotted owls at 37 sites would likely be adversely affected by the proposed action (Table 15). In total, 2,448 acres of NRF would be removed or downgraded within spotted owl home ranges associated with the Bear Grub and Round Oak Projects (579 acres in Bear Grub and 1,869 acres in Round Oak) (Assessment, p. 41). The amount of NRF removal within the spotted owl home range scale ranges from 0.2 acres up to 360 acres. Adverse effects to spotted owls are anticipated because the quantity and quality of habitat would be diminished, likely result in reductions to reproduction, survival, feeding and sheltering. Any potential harm to occupied spotted owl sites is discussed below.

Adverse effects are also anticipated at spotted owl sites where the current amount of NRF habitat in the core-use area is below the habitat range as informed by best available information *and* where substantial amounts of dispersal-only habitat removal (see below) or NRF habitat modification are proposed within the core-use area. Treatments in these specific core-use areas would exacerbate the overall poor habitat conditions at sites 0971O and 4079O and therefore, treatments are likely to adversely affect spotted owl occupying these sites.

While adverse effects to occupied spotted owl home ranges may occur, treatments are proposed in forested stands where the existing conditions have formed from fire suppression and/or ingrowth subsequent to management. The intent is that long-term benefits to spotted owls would result compared to no action, because the vegetation structure would more closely resemble those found historically in the respective watersheds/action areas. Some of these habitats are classified as either relatively lower quality NRF or F for spotted owls. The Service recognizes that impacts to spotted owl habitats may be necessary to maximize treatment efficacy. For example, to achieve stand resiliency and moderating fire behavior, conservative silvicultural prescriptions have been found to be ineffective (Roloff et al. 2005, pp. 178-180). Increasing the intensity of treatments and focusing treatments in vegetation types associated with frequent fire regimes, (active management) and that are not associated with spotted owl core –use areas was found to result in lower crown fire potential than no management (Roloff et al. 2012, pp. 4-6).

***Occupancy Status of Spotted Owls Likely to be Adversely Affected***

Because spotted owl protocol surveys are ongoing at the time of this consultation, current spotted owl occupancy information is not available for all of the sites. However, for *planning purposes* for the projects in this consultation, the District has determined occupancy status based on current survey information (Table 16) and is subject to change once surveys have been completed. If resident spotted owls are found occupying where adverse effects are determined due to habitat modification, the District will defer and/or modify their harvest plans to reduce the likelihood of incidental take of spotted owls and/or reinitiate consultation, as appropriate. This process would be conducted through the Rogue Basin Level 1 Team, as appropriate.

For the Bear Grub action area, current survey information indicates that 23 sites are considered as not having resident spotted owls whereas at 2 sites, 3941O and 4611O, occupancy status is undetermined at this time. Because of private land considerations of these 2 sites, resulting in survey delays which have recently been overcome, the District anticipates conducting full protocol surveys as necessary for project clearance. As noted above, if owls are located, the District will defer and/or modify their harvest plans to reduce the likelihood of incidental take of spotted owls.

For the Round Oak action area, current survey information indicates 2 sites with resident spotted owls whereas 16 sites do not have detections sufficient enough to ascertain occupancy.

**Table 15. Occupancy Status Summary of Spotted Owl Sites Affected by the Bear Grub and Round Oak FY20 Batch of Projects, Medford District BLM.**

| | Surveys are Current (at least 2 years of protocol surveys) | | Occupancy Status Currently Unknown (Protocol Surveys Not Completed, or Not Enough Information) |
|---|---|---|---|
| | Occupied (Pair or Resident Single) | Unoccupied (No Pairs or Resident Singles) | |
| **Bear Grub** | **0** | **23** | **2** |
| | | *0096O, 0097O, 0114O, 0592O, 0944O, 0971O, 0972O, 0973A, 0992O, 2234O, 2260B, 2267O, 2361O, 2394O, 2395O, 2397O, 3559O, 3648O, 3934O, 3942O, 4066O, 4068O, 4513O* | *3941O, 4611O* |
| **Round Oak** | **2** | **16** | **0** |
| | *2220O, 3561B* | *1163O, 1826B, 1831A/1831O, 1957B/1957F, 1958A, 2007B, 2059A/2059O, 2222A/2222O, 2359O, 2360A, 3260O, 4079O, 4616O, 4620O, FS-DD, FS-OM* | |
| **TOTAL** | **2** | **39** | **2** |

***Spotted Owls Not Likely to be Adversely Affected from the Proposed Action:***
Of the 43 total spotted owl sites, spotted owls at 6 sites (Table 15) would not be adversely affected by the proposed action. This is because the proposed action is not expected to measurably impact habitat for nesting or foraging activities, which could affect reproduction and survival of spotted owls associated with the sites. Adverse effects are not expected at the majority of these sites because the proposed treatments would only *modify* the stand conditions, and therefore habitat function would be retained post-harvest.

Round Oak sites 2220O and 3561B are both occupied, but adverse effects are not expected to occur from the proposed action. Site 2220O has no proposed treatments in NRF, and no proposed treatment at the core or nest patch scale. For this site, there will be a total of approximately 78 acres of dispersal-only quality habitat removed at the home range scale and no other treatments. Site 3561B has approximately 0.3 acres of proposed NRF removal at the home range scale and approximately 17 acres of dispersal-only removal proposed at the HR scale. This site has no proposed treatment at the core or nest patch scale (Table 16 herein).

Similar to the LAA sites listed above, if spotted owls are located during surveys that represent a change in site location or some other change in circumstances that warrants a reevaluation of the effects determination, the District will consider modifying or dropping units to avoid incidental take, as appropriate. This process would be conducted through the Rogue Basin Level 1 Team, as appropriate.

In summary, of the 43 sites with treatment units, site-specific conditions lead the Level 1 Team to determine that the proposed action may affect and is likely to adversely affect spotted owls at 37 sites. This finding is based on a site by site pre and post-treatment habitat evaluation and the situational context. Any site with treatments to NRF habitat underwent additional scrutiny to ensure there would be minimal risk of incidental take and that treatments are consistent within the RMP (SWO RMP/ROD) (USDI BLM 2016a) as consulted by the Service (USDI FWS 2016). The District is conducting surveys for spotted owls and the proposed action will be modified by the District when sites are determined to be occupied and if incidental take is likely.

## Table 16. Detailed Spotted Owl Site Effects for the Bear Grub and Round Oak FY20 Batch of Projects, Medford District BLM.

| Project | NSO SITE | EFFECTS | NRF HR acres Pre-Treat | NRF HR % Pre-Treat | NRF Core acres Pre-Treat | NRF Core % Pre-Treat | NRF Acres Removed | | | NRF Acres Downgraded | | | NRF Acres Modified (Function Maintained) | | | Dispersal Acres Removed | | | Dispersal Acres Modified (Function Maintained) | | | HR NRF Reduced (acres) | HR NRF acres Post-Treat | HR NRF % Post-Treat | NRF Core Reduced (acres) | NRF Core acres Post-Treat | NRF Core % Post-Treat | Occupancy Status (codes on the last page) | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | HR | Core | NP | HR | Core | NP | HR | Core | NP | HR | Core | NP | HR | Core | NP | | | | | | | 2018 | 2019 | |
| Bear Grub[1] | 0096O | LAA | 944 | 28% | 261 | 52% | 29 | 17 | 0 | 30 | 14 | 1 | 16 | 3 | 0 | 109 | 27 | 0 | 56 | 20 | 3 | 59 | 885 | 26% | 31 | 230 | 46% | NO | NO + | |
| Bear Grub[1] | 0097O | LAA | 731 | 22% | 130 | 26% | 36 | 0 | 0 | 16 | 0 | 0 | 0 | 0 | 0 | 24 | 0 | 0 | 0 | 0 | 0 | 52 | 679 | 20% | 0 | 130 | 26% | NO | NO + | |
| Bear Grub[1] | 0114O | LAA | 679 | 20% | 35 | 7% | 17 | 0 | 0 | 14 | 0 | 0 | 40 | 0 | 0 | 31 | 0 | 0 | 39 | 0 | 0 | 31 | 648 | 19% | 0 | 35 | 7% | UNK-obs | NO + | |
| Bear Grub[1] | 0592O | LAA | 1078 | 32% | 57 | 11% | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 22 | 1056 | 31% | 0 | 57 | 11% | NO | NO + | |
| Bear Grub | 0944O | LAA | 576 | 17% | 78 | 16% | 141 | 30 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 46 | 5 | 0 | 4 | 4 | 0 | 141 | 435 | 13% | 30 | 48 | 10% | NO | NO + | |
| Bear Grub | 0971O | LAA | 252 | 7% | 128 | 26% | 0 | 0 | 0 | 0 | 0 | 0 | 80 | 80 | 43 | 56 | 0 | 0 | 52 | 0 | 0 | 0.0 | 252 | 7% | 0 | 128 | 26% | UNK-obs | NO | |
| Bear Grub[1] | 0972O | LAA | 841 | 25% | 182 | 36% | 42 | 0 | 0 | 23 | 0 | 0 | 6 | 0 | 0 | 78 | 0 | 0 | 31 | 0 | 0 | 65 | 776 | 23% | 0 | 182 | 36% | NO | NO | |
| Bear Grub[1] | 0973A | LAA | 647 | 19% | 134 | 27% | 77 | 12 | 0 | 20 | 5 | 0 | 11 | 0 | 0 | 36 | 1 | 0 | 22 | 7 | 0 | 97 | 550 | 16% | 17 | 117 | 23% | NO + | NO + | |
| Bear Grub[1] | 0992O | LAA | 846 | 25% | 193 | 39% | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 9 | 837 | 25% | 0 | 193 | 39% | NO + | NO + | |
| Bear Grub[1] | 2234O | LAA | 681 | 20% | 284 | 57% | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 677 | 20% | 0 | 284 | 57% | NO | NO | |
| Bear Grub[1] | 2260B | LAA | 277 | 8% | 75 | 15% | 0 | 0 | 0 | 8 | 8 | 3 | 0 | 0 | 0 | 120 | 70 | 11 | 44 | 44 | 15 | 8 | 269 | 8% | 8 | 67 | 13% | NO | NO | |
| Bear Grub[1] | 2267O | LAA | 516 | 15% | 162 | 32% | 10 | 2 | 0 | 0 | 0 | 0 | 227 | 34 | 0 | 76 | 3 | 0 | 3 | 0 | 0 | 10 | 506 | 15% | 2 | 160 | 32% | NO | NO | |
| Bear Grub[1] | 2361O | LAA | 605 | 18% | 171 | 34% | 37 | 12 | 0 | 5 | 5 | 0 | 11 | 0 | 0 | 19 | 3 | 0 | 33 | 5 | 0 | 42 | 563 | 17% | 17 | 154 | 31% | NO + | NO + | |
| Bear Grub | 2394O | LAA | 345 | 10% | 59 | 12% | 47 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 15 | 0 | 0 | 47 | 298 | 9% | 0 | 59 | 12% | NO | NO | |
| Bear Grub[1] | 2395O | NLAA | 695 | 20% | 307 | 61% | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 694.8 | 20% | 0 | 307 | 61% | NO | NO + | |
| Bear Grub | 2397O | LAA | 971 | 29% | 230 | 46% | 133 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 133 | 838 | 25% | 0 | 230 | 46% | NO + | NO + | |
| Bear Grub[1] | 3559O | NLAA | 466 | 14% | 83 | 17% | 0 | 0 | 0 | 0 | 0 | 0 | 227 | 12 | 0 | 64 | 13 | 0 | 52 | 13 | 0 | 0 | 466 | 14% | 0 | 83 | 17% | NO | NO | |
| Bear Grub[1] | 3648O | LAA | 992 | 29% | 202 | 40% | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 0 | 0 | 0 | 0 | 0 | 29 | 963 | 28% | 0 | 202 | 40% | NO + | NO + | |
| Bear Grub | 3934O | LAA | 458 | 13% | 76 | 15% | 33 | 0 | | 0 | 0 | 0 | 142 | 0 | 0 | 52 | 0 | 0 | 18 | 0 | 0 | 33 | 425 | 13% | 0 | 76 | 15% | NO | M-obs | |
| Bear Grub | 3941O | LAA | 724 | 21% | 24 | 5% | 34 | 0 | 0 | 16 | 6 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 50 | 674 | 20% | 6 | 18 | 4% | NO | NS | |
| Bear Grub | 3942O | LAA | 292 | 9% | 87 | 17% | 75 | 24 | 2 | 0 | 0 | 0 | 42 | 40 | 22 | 19 | 8 | 0 | 9 | 8 | 0 | 75 | 217 | 6% | 24 | 63 | 13% | UNK-obs | NO + | |
| Bear Grub | 4066O | LAA | 721 | 21% | 73 | 15% | 52 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 0 | 0 | 0 | 0 | 0 | 52 | 669 | 20% | 0 | 73 | 15% | NO | NO + | |
| Bear Grub[1] | 4068O | LAA | 1065 | 31% | 205 | 41% | 64 | 0 | 0 | 39 | 15 | 0 | 16 | 2 | 0 | 111 | 23 | 0 | 43 | 6 | 0 | 103 | 962 | 28% | 15 | 190 | 38% | NO | NO | |
| Bear Grub[1] | 4513O | LAA | 514 | 15% | 136 | 27% | 28 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 38 | 7 | 0 | 42 | 0 | 0 | 28 | 486 | 14% | 20 | 116 | 23% | NO | NO | |
| Bear Grub[1] | 4611O | LAA | 493 | 15% | 81 | 16% | 37 | 0 | 0 | 7 | 0 | 0 | 13 | 0 | 0 | 22 | 14 | 0 | 23 | 0 | 0 | 44 | 449 | 13% | 0 | 81 | 16% | NS + | NS + | |
| Round Oak[1] | 1163O | LAA | 487 | 17% | 160 | 32% | 222 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 222 | 265 | 9% | 40 | 120 | 24% | NO | NO | |
| Round Oak[1] | 1826B | LAA | 870 | 30% | 156 | 31% | 312 | 83 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 6 | 2 | 0 | 0 | 0 | 312 | 558 | 19% | 83 | 73 | 15% | NO + | NO + | |
| Round Oak | 1831A | LAA | 642 | 22% | 136 | 27% | 283 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 283 | 359 | 12% | 24 | 112 | 22% | NO + | NO + | |
| Round Oak | 1831O | LAA | 724 | 25% | 295 | 59% | 311 | 92 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 73 | 1 | 0 | 0 | 0 | 0 | 311 | 413 | 14% | 92 | 203 | 41% | | | |
| Round Oak[1] | 1957B | LAA | 701 | 24% | 147 | 29% | 109 | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 109 | 592 | 20% | 44 | 103 | 21% | NO + | M-obs + | |
| Round Oak[1] | 1957F | LAA | 973 | 34% | 144 | 29% | 237 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 237 | 736 | 25% | 6 | 138 | 28% | | | |
| Round Oak[1] | 1958A | LAA | 778 | 27% | 118 | 24% | 43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 735 | 25% | 0 | 118 | 24% | NO + | NO | |
| Round Oak | 2007B | NLAA | 237 | 8% | 86 | 17% | 0 | 0 | 0 | 0 | 0 | 0 | 98 | 0 | 0 | 0 | 0 | 0 | 119 | 26 | 0 | 0 | 237 | 8% | 0 | 86 | 17% | NO | NO | |

## Table 16: Detailed Spotted Owl Site Effects for the Bear Grub and Round Oak FY20 Batch of Projects, Medford District BLM.

| Project | NSO SITE | EFFECTS | NRF HR acres Pre-Treat | NRF HR % Pre-Treat | NRF Core acres Pre-Treat | NRF Core % Pre-Treat | NRF Acres Removed | | | NRF Acres Downgraded | | | NRF Acres Modified (Function Maintained) | | | Dispersal Acres Removed | | | Dispersal Acres Modified (Function Maintained) | | | HR NRF Reduced (acres) | HR NRF acres Post-Treat | HR NRF % Post-Treat | NRF Core Reduced (acres) | NRF Core acres Post-Treat | NRF Core % Post-Treat | Occupancy Status (codes on the last page) | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | HR | Core | NP | HR | Core | NP | HR | Core | NP | HR | Core | NP | HR | Core | NP | | | | | | | 2018 | 2019 | |
| Round Oak[1] | 2059A | LAA | 441 | 15% | 109 | 22% | 231 | 66 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 1 | 0 | 0 | 0 | 0 | 231 | 210 | 7% | 66 | 43 | 9% | NO | NO+ | |
| Round Oak[1] | 2059O | LAA | 494 | 17% | 151 | 30% | 190 | 125 | 47 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 190 | 304 | 11% | 125 | 26 | 5% | NO | NO+ | Barred owls nested |
| Round Oak | 2220O | NLAA | 926 | 32% | 238 | 48% | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 78 | 0 | 0 | 0 | 0 | 0 | 0 | 926 | 32% | 0 | 238 | 48% | PAIR | PAIR | |
| Round Oak | 2222A | NLAA | 778 | 27% | 64 | 13% | 0 | 0 | 0 | 0 | 0 | 0 | 32 | 0 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 778 | 27% | 0 | 64 | 13% | UNK-obs | NO | |
| Round Oak | 2222O | NLAA | 560 | 19% | 5 | 1% | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 0 | 0 | 0 | 0 | 0 | 45 | 0 | 0 | 0 | 560 | 19% | 0 | 5 | 1% | | | |
| Round Oak | 2359O | LAA | 751 | 26% | 164 | 33% | 254 | 118 | 54 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 2 | 0 | 0 | 0 | 0 | 254 | 497 | 17% | 118 | 46 | 9% | UNK-obs + | NO | |
| Round Oak | 2360A | LAA | 403 | 14% | 130 | 26% | 152 | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 1 | 0 | 0 | 0 | 0 | 152 | 251 | 9% | 34 | 96 | 19% | F-obs + | NO + | |
| Round Oak[1] | 3260O | LAA | 929 | 32% | 192 | 38% | 305 | 150 | 64 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 7 | 2 | 0 | 0 | 0 | 305 | 624 | 22% | 150 | 42 | 8% | NO | NO + | |
| Round Oak | 3561B | NLAA | 548 | 19% | 260 | 52% | 0.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 547.7 | 19% | 0 | 260 | 52% | PAIR | PAIR | |
| Round Oak | 4079O | LAA | 336 | 12% | 177 | 35% | 0 | 0 | 0 | 0 | 0 | 0 | 108 | 68 | 13 | 0 | 0 | 0 | 66 | 7 | 0 | 0 | 336 | 12% | 0 | 177 | 35% | NO | NO + | |
| Round Oak | 4616O | LAA | 679 | 23% | 158 | 32% | 360 | 62 | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 40 | 9 | 3 | 3 | 0 | 0 | 360 | 319 | 11% | 62 | 96 | 19% | NO + | UNK-obs | |
| Round Oak | 4620O | LAA | 228 | 8% | 96 | 19% | 50 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 50 | 178 | 6% | 8 | 88 | 18% | NO | NO | |
| Round Oak[1] | FS-DD | LAA | 1163 | 40% | 233 | 47% | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 25 | 1138 | 39% | 0 | 233 | 47% | NO | NO | |
| Round Oak[1] | FS-OM | LAA | 1094 | 38% | 146 | 29% | 151 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 151 | 943 | 33% | 0 | 146 | 29% | NO | M-obs | |

*1 = Site Center is in Designated Critical Habitat*

| OCCUPANCY CODES | |
|---|---|
| NO | Not Occupied (protocol surveys) |
| RSM | Resident Male |
| RSF | Resident Female |
| PAIR | Pair |
| M-obs | Male, not enough for RS |
| F-obs | Male, not enough for RS |
| MF-obs | M/F - not enough for RS or Pair |
| UNK-obs | Unknown STOC - not enough for RS |
| NS | Not Surveyed |
| NR | No Response |
| (+) BO | Barred Owl |

**Habitat with Modify Prescriptions – Fuels reduction**

Collectively, for the fuels reduction activities of prescribed fire (including understory burning which is expected to prune conifers and hardwoods within a couple feet of the ground, not affecting the overstory and treatments for slash), there could be indirect short-term impacts to spotted owl prey habitat in that prey species forage conditions and travel pathways could temporarily be modified. However, portions of the area will not undergo underburning and will leave prey habitat intact. Further, prescribed fire burns at different rates and intensities may establish diffuse edges (Sakai and Noon 1993) and are likely to be good habitat for woodrats (*Neotoma spp*) (Sakai and Noon 1993). Diffuse edges may also create better access for hunting small mammals (Zabel et al. 1992 a and b) and Ward et al. 1998), in general, while simultaneously providing adjacent closed canopy cover habitat. This proposed action should create just these types of habitats by burning some areas which will regenerate into suitable habitat for many types of small mammals and leaving areas unburned as habitats for other small mammals such as woodrats.

The proposed action is not intended to affect the mid and upper story canopy. However, recent research has recently demonstrated a preference by spotted owls for areas with more developed understory, at least as compared to areas preferred by barred owls (Jenkins et al. 2019, pp. 3-4). The prescribed burns is likely to reduce habitat suitability in the understory throughout portions of the proposed burn areas because, in general, ladder fuels such as surface fuels –shrubs- and small diameter trees will likely be removed due to the burns. The understory burning is not anticipated to effect upper canopy microclimate conditions and concealment cover from predators because these mid to upper story portions of the canopy are not expected to be modified by the proposed action.

Bond et al. (2009) found that California spotted owls selected areas that burned at low and moderate severity for roosting and foraging. The authors suggested that increased prey availability (woodrats) explains the increased use by spotted owls. The Service expects that spotted owls will continue to use the post-prescribed fire stands because habitat conditions are likely to be similar to low severity wildfire conditions and the availability of woodrats for spotted owl foraging.

**Habitat with Modify Prescriptions – Tree Harvest**

Approximately 34 percent (of acres) of the District's FY20 Batch of Projects include modify prescriptions intended to maintain habitat function. This includes 906 acres of NR and F habitat and 1,166 acres of dispersal- only habitat (Table 12). Some of the planned treatments will impact the condition of the stands due to the removal of larger trees. The following weighs the best available information related to spotted owl response to thinning related activities, which is varied. For example, as overviewed in the Revised Recovery Plan for the Northern Spotted Owl (USDI FWS 2011), most of the data on thinning effects were collected incidental to larger research objectives and the studies were generally not designed or intended to develop future spotted owl habitat. A theme from Forsman et al. (1984) suggests that harvest, particularly higher intensity timber harvest such as regeneration or heavy tree selection (most likely resembling NRF removal and downgrade), close to the nest and when the sites had low amounts of habitat, had negative impacts to spotted owls (e.g., decreased reproduction and site abandonment). Meiman et al. (2003) recommended that harvest operations not be conducted

near spotted owl nest sites, which indicated that a spotted owl in their study moved its core-use area away from thinned areas. However, Anthony and Wager (1998) and Zabel et al. (1992b) found spotted owls using stands with some overstory removal and thinning from below. In the case of Anthony and Wager (1998), their study was conducted several years post-treatment so initial spotted owl response is unknown. Irwin et al. (2015 p. 236) did not observe site abandonment as a result of thinning or partial harvest of young stands. Overall, given the small number of spotted owls studied, the information provided in these studies is insufficient for drawing firm conclusions about the effects of thinning prescriptions on spotted owls (USDI FWS 2011, III-15). Further confounding the ability to make definitive statements regarding the effects of thinning is that none of the available studies were conducted with the specific intent to maintain or enhance spotted owl habitat but rather the best available information while informative, is ancillary. However, after weighing this information, it is the Service's view that opportunities do exist to conduct vegetation management to enhance development of late-successional forest characteristics or meet other restoration goals in a manner compatible with retaining resident spotted owls (USDI FWS 2011, III-14); albeit weighing the trade-offs with the site specific circumstances, including the spatial location of the treatments relative to the nest site and core-use area.

Despite consistent patterns of habitat selection by spotted owls, structural conditions of forest habitats occupied by spotted owls are highly variable. This is particularly evident in the diverse conifer-hardwood forests of the southern Oregon, including the Oregon Klamath and Oregon West Cascades Provinces, relative to the more northerly moist Douglas-fir-hemlock forests/Provinces, where spotted owl home ranges are larger (Zabel et al. 1995) and habitat preferences are narrower. This includes the use of foraging habitat (including RF habitat as under evaluation here), which is the most variable and spatially extensive of all habitats used by territorial spotted owls (USDI FWS 1992, p. 20). The descriptions of foraging habitat in the Klamath Province rely on published and unpublished studies, including work conducted on the California spotted owl in the northern Sierra Nevada (e.g., Irwin et al. 2007, 2012, 2015 and Zabel et al. 1992a and b). Much of the California spotted owl studies were conducted in a mixed-conifer/hardwood forest similar to forest types used by northern spotted owls in the Klamath and south Cascades ecosystems. Although spotted owls often selectively foraged in older forest, these telemetry studies show that they also use a relatively wide range of forest structure (Irwin et al. 2004 and 2007 and Zabel et al. 1992 a and b), supporting the Service's view that some forms of forest thinning can be compatible with retaining resident spotted owls.

Descriptions of foraging habitat have ranged from complex structure (Solis and Gutierrez 1990, pp. 742-744) to forests with lower canopy (cover or closure) and smaller trees than forests containing nests or roosts (Gutierrez 1996, pp. 3-5). Forest structural features typically used to describe spotted owl foraging habitat include canopy cover (or closure), tree size and basal area. Other attributes such as tree species composition, canopy layering (Anthony and Wagner 1998, Mills et al. 1993 and North et al. 1999), presence of edges and small openings and landscape position were influential in several studies (Zabel et al. 1995, Ward et al. 1998 and Irwin et al. 2007 and 2012). As discussed above, ***all*** of the fundamental elements of spotted owl habitat need to be considered in the evaluation; none of the elements should be considered in isolation when evaluating impacts due to thinning. It should be noted that a description of foraging habitat likely represents the range of stand conditions used by spotted owls at night, and may not represent the specific habitat qualities of sites where spotted owls successfully obtain prey.

However, researchers have concluded that spotted owls will select old forests for foraging at the landscape scale (Carey et al. 1992, pp. 236-237 and Carey and Peeler 1995, p. 235) but will also forage in younger stands with high prey densities and access to prey (Carey et al. 1992, p.247, Rosenberg and Anthony 1992, p. 165, and Thome et al. 1999, pp. 56-57). Irwin et al. (2012, pp. 209-10) found that spotted owls in the mix-conifer region would often forage within more open stands that contained brush or a low basal area of conifer trees, and that presence of a few scattered trees or snags likely facilitated hunting for prey such as woodrats. Hardwoods within stands are also an important structural element in some of the dry forest study areas (Irwin et al. 2012, p. 209). Our evaluation of the information regarding treatments intended to maintain spotted owl habitat are consistent with and based on the high degree of stand conditions and site variability in "foraging" habitat used by spotted owls.

Most of the aforementioned studies suggested some degree of selection for higher basal areas (150 to 220 $ft^2$/ac) but a substantial amount of foraging (44 percent) occurred within stands with basal areas ranging from 80 to 160 $ft^2$/acre (USDI FWS 2009 and Irwin et al. 2007 and 2012). Residual basal area appears to be the most important part of the prescription (Irwin et al. 2015, p. 240: 25-35 $m^2$/ha basal area [109 to 152 $ft^2$]). For the District's FY20 Batch of Projects, the intended post-treatment basal area (greater than 150 $ft^2$/acre) (Assessment, p. 22) target for NRF and F modify prescriptions are well within the foraging structural conditions of known spotted owl foraging use patterns in mixed-conifer dry forests.

Based on radio telemetry locations, Zabel et al. (1992a) considered stands with at least 40 percent canopy cover could be considered as foraging habitat (Zabel et al call it closure but they evaluated canopy from aerial photography which typically translate to cover). Although, Zabel et al. (2003) found that from 18 to 40 percent of foraging locations occurred in stands with 20 to 39 percent canopy cover, Irwin et al. (2007) did not find significant relationships with canopy cover. Overall, species diversity and vertical structure are anticipated to improve, providing more resilient stands (see Table 16 herein for projected outcomes).

As mentioned elsewhere in this opinion, there are distance relationships that spotted owls display (Rosenberg and McKelvey 1999, Schilling et al.2013, Swindle et al. 1999, Irwin et al. 2015). In that: spotted owls will use parts of their home ranges more intensively than other areas and use certain topographic locations, such as upper slopes and ridgetops, less than expected (Irwin et al. 2012). When thinning projects are located outside of nest patches and core-use areas - treatments under the proposed action are for the most part, located outside of occupied core-use areas (Table 16) and toward the outer portions of the home range - the actual use of stands will likely vary depending on relative habitat quality and abiotic factors; and, as mentioned above, it has been recommended that harvests, such as thinning, should occur outside spotted owl core-use areas because of relatively less impact to the owl when projects are located farther to the perimeter of the home range.

As provided above in this section, the District's modify prescriptions are intended to retain structural features of spotted owl habitat, such as basal area, layering, canopy cover and large trees within ranges provided for in the best available information, along with other elements such as shrubs and decadent features, to the extent possible. Under the proposed action up to 14 of the spotted owl sites have core-use areas (neither of the sites are occupied) proposed for modify prescriptions, ranging from 2-80 acres (collectively for NRF, F and dispersal-only) (Table 16).

The District's proposed targeted outcome of post-stand condition in terms of basal area retention, layers, canopy cover and other key stand features are within the range of habitat conditions of spotted owl habitat use areas, as informed by best available information. As described in the PDC section above, District wildlife and forestry staff will work together to develop and implement prescriptions to maintain spotted owl habitat per the prescriptions and will change the prescriptions and implementation procedures as needed to fulfill this PDC. Therefore, the function of the habitat, post-treatment, is anticipated to be maintained and not likely to adversely affect spotted owls.

**Proposed Treatments Outside of Known Home Ranges**

The Bear Grub and Round Oak projects are proposing to treat 1,691 acres (28 percent of total project habitat acres treated) of spotted owl habitat outside of home ranges of known spotted owl sites. These acres are a subset of the total project acres listed in Table 12 above and further summarized by project in Table 17. As such, this habitat (as well as other habitats not being treated in the action areas – see above) is available to spotted owls if movements occur due to the proposed action. For example, this habitat would be available for spotted owl foraging and a shift in a future nest site.

Spotted owl protocol surveys to all NRF outside of known home ranges are ongoing and if new resident spotted owls are found, the District plans to drop units or modify proposed prescriptions to avoid and minimize or avoid adverse effects and avoid incidental take. To date, no spotted owls have been observed outside of known home ranges in the Bear Grub or Round Oak Projects in the last 2 years (Assessment, p.42). As indicated above, surveys in these project areas will continue and if resident spotted owls are located, the units will be dropped or modified to minimize or avoid adverse effects that lead to a determination of harm.

**Table 17. Effects to Spotted owl Habitat Outside of Known Home Ranges for the Bear Grub and Round Oak Action Areas, Medford District BLM.**

| | NRF Removed (acres) | | NRF Downgraded (acres) | | NRF Modify (acres) | | Dispersal-Only Removed (acres) | Dispersal-Only Modify (acres) | Total Habitat Acres Treated |
|---|---|---|---|---|---|---|---|---|---|
| | NR[1] | F[2] | NR[1] | F[2] | NR[1] | F[2] | | | |
| **Bear Grub** | 6 | 168 | 0 | 0 | 2 | 235 | 70 | 512 | **993** |
| **Round Oak** | 161 | 316 | 0 | 0 | 22 | 108 | 73 | 17 | **698** |
| **TOTAL** | **167** | **484** | **0** | **0** | **24** | **343** | **143** | **529** | **1,691** |

1- NR = Nesting/Roosting
2- F = Foraging

**Take Avoidance**

Under the RMP/ROD (USDI BLM 2016a, pp. 121 and 127), the BLM will avoid actions that would cause the incidental take of spotted owls from timber harvest. As determined above, adverse effects to spotted owls is anticipated at 37 sites. While adverse effects are anticipated, those effects do not necessarily mean that harm occurs. For significant impairment (harm) to occur to spotted owls at the 37 sites with adverse effects, there must be reasonable certainty that resident/territorial spotted owls are likely to ***occupy*** the affected sites ***and*** biologically respond to altered habitat conditions in a manner that corresponds to the regulatory and statutory definitions of take (USDI FWS 2002 and USDI FWS 2018a). For the Bear Grub and Round Oak proposed actions, spotted owl protocol surveys have been conducted. Spotted owl occupancy (as a resident spotted owl), inform the take analysis; that is, if effects of the action are reasonably certain to occur. In general, when less than 40 to 60 percent of a home range is NRF habitat, the likelihood of spotted owl presence is lower, and the likelihood of spotted owl survival and successful reproduction is lower (see Appendix A below, the Spotted Owl Resource Use section above, and Figure 4-7 in Lesmeister et al. 2018b). These central tendency values, along with site-specific conditions, and other best available information, inform the Service's determination of take. However, there are exceptions to the central tendency values as discussed above (e.g., Bart and Forsman 1992) and these are taken into consideration in the evaluation of take.

Adjacent private lands have removed or could remove potential NRF on their lands within spotted owl home ranges. As discussed in the Cumulative Effects section of the Assessment (p. 53), the District indicates that spotted owl habitat conditions on intermingled private lands are not likely contributing to any meaningful extent to spotted owl occupancy.

Of the 37 sites likely to be adversely affected by the proposed action, 0 sites are currently occupied by resident spotted owls and 35 sites (Assessment Appendix B, Table B-1 and Table 16 herein) are not occupied as determined through current protocol surveys (USDI FWS 2012a). The occupancy status of the two remaining sites are unknown pending completion of ongoing protocol surveys.

Because recent protocol surveys indicate that spotted owls are not currently present at the 35 sites (Assessment Appendix B, Table B-1), it is the Service's opinion that the proposed action is not reasonably certain to result in the incidental take of spotted owls at these sites.

The proposed action will result in adverse effects to spotted owls at 0 occupied sites at present, but the two unknown sites 3941O and 4611O in the Bear Grub Action Area are both LAA. The District plans to survey these core-use areas because access was recently granted to site 4611O and a public access point was located for site 3941O. Once the surveys are completed, the District will meet with the Service to determine the appropriate consultation coverage for these sites.

The spotted owl sites and proposed harvest units included in this consultation are subject to the District conducting *Complete Protocol Surveys* (Assessment) prior to modifying spotted owl habitat (USDI FWS 2012a). When resident spotted owls are located, the District will modify proposed actions, as necessary, to avoid incidental take of spotted owls. The Service will

provide technical assistance through the Level 1 process in making recommendations for minimizing adverse impacts and avoiding incidental take of spotted owls.

**Effects of the Action on Spotted Owl Prey Species**

Treatments, such as commercial harvest, selection harvest and other activities that negatively alter the canopy and understory of forest stands may affect habitat elements important to small mammals and can result in direct injury or mortality of individuals, depending on scope and scale of treatments. Reductions in habitat components such as canopy connectivity and cover such as shrubs, down wood, and snags, may subsequently affect small mammal abundance and diversity (Chambers 2002; Manning et al., 2011); however positive response of some components of prey habitat such as herb-grass cover, understory vegetation, understory species richness) have been observed after fuels treatments (Manning and Edge 2008 p. 628, Dodson and Peterson 2010 p. 1704). Other findings indicate thinning can have short-term negative effects on understory plants (mechanical destruction) and below- ground fungi (death of host trees and mechanical destruction; Courtney et al. 2004). In turn these effects may affect the food sources used by small mammals (Converse et al., 2006, Amacher et al., 2008, Dodson and Peterson 2010, Manning and Edge 2008; Suzuki and Hayes 2003). Although small mammals seem to recolonize areas soon after disturbance, diversity and species dominance differ as succession progresses. Verschuyl et al. (2011, p. 227) reported positive medium- and long-term response to forest thinning by mammals across all forest types and thinning intensities but noted that the effects of forest thinning on species of conservation concern may warrant further review.

The northern flying squirrel, dusky-footed woodrat, bushy-tailed woodrat, and red tree voles are important prey of the northern spotted owl in this action areas (Forsman, et al. 2004).

Dusky-footed woodrats occur in a variety of conditions, including old, structurally complex forests, younger seral stages, and shrubby openings, and are often associated with streams (Carey et al. 1999, Sakai and Noon 1993, Hamm and Diller 2009). The Project prescriptions and implementation of PDCs will reduce, but are expected to variably retain important habitat components (hardwoods, snags, woody debris, shrubs) during treatments. Oaks (*Quercus* spp.), other mast producing hardwoods, and shrubs provide a key food resource for dusky-footed woodrats and shrubs may be important sources of cover from predators. Forms of thinning that create substantial canopy openings could reduce habitat suitability for woodrats in the short-term but subsequently create benefits if increases in growth of shrubs or hardwoods (Innes et al. 2007) follow after thinning. Conversely, thinning or associated practices (e.g., burning slash piles) could be detrimental to dusky-footed woodrats if hardwoods, shrubs, or down logs are reduced. A study of dusky-footed woodrats in the redwood region of California, however, did not find an association between abundances of woodrats and different intensities of commercial thinning (Hamm and Diller 2009). Gaps, no treatment ‘skips’, and retention of riparian habitats will enhance the fine-scale diversity of vegetation and should maintain overall populations of dusky-footed woodrats in the long-term. Short-term effects are largely dependent on the large-and fine-scale spatial distribution of existing habitats and the proportion of the habitat affected.

Studies of the effects of vegetation management on flying squirrels have found similarly mixed results, likely due to variability in stand conditions and treatment intensity of study areas.

Depending on the prescription and initial conditions, thinning and other forms of partial harvesting can affect a squirrel's ability to glide or avoid predation. For example, NRF habitat removal and possibly downgrade would likely remove flying squirrel habitat and decrease flying squirrel abundance (Wilson 2010 and Manning et al. 2011). Thinning can also destroy decaying or defective woody materials; increase their recruitment; or both. In a study conducted in the Sierra Nevada of California (similar ecotype as the FY20 Batch of Projects), abundances of flying squirrels in thinned stands appeared related to the amount of canopy cover retained during harvesting; though authors noted that the study was limited in scope and sampling effort (Meyer et al. 2007, pp.206-207). Canopy was also found to be positively correlated with flying squirrel density in another study (Sollmann et al. 2016, p. 104-106). Other studies have suggested that food availability influences flying squirrel abundance, and commercial thinning modifies microsite conditions and can temporarily (e.g., <20 years) reduce the availability of truffles, and other hypogeous fungi which are key food resources for flying squirrels and other small mammals (Waters et al. 1994, Luoma et al. 2003, Gomez et al, 2005). Comparing flying squirrel densities in thinned and un-thinned treatments, flying squirrel densities were found to be lowest in thinned units, that flying squirrels shifted into un-thinned patches toward un-harvested areas that retained higher percent canopy, but overall flying squirrel densities at larger spatial scales did not decline (Sollmann et al. 2016, pp. 104-106). Management recommendations for flying squirrel conservation in the papers cited above include the retention of the existing environmental heterogeneity, specifically, avoidance of large openings, the retention of large logs and snags and escape cover, and connectivity within the canopy to facilitate gliding.

Surveys for red-tree voles were not conducted because the FY20 Batch of Projects are under the 2016 SWO RMP/ROD so Survey and Manage surveys are not required (USDI BLM 2016a, pp. 27-28) and the Bear Grub and Round Oak action areas are outside the newer red tree vole zones. As a result, some undiscovered nests may be removed as a result of the proposed action. Red tree voles and their habitat would be negatively affected due to reduced canopy cover, isolating nests, and reducing dispersal capability. However, even with the loss of some nests and habitat from the proposed action, red tree voles are likely to persist in action area because spotted owl habitat would remain throughout the action areas. Red-tree voles are not federally listed species.

The FY20 Batch of Projects plans to implement harvest in a manner that would distribute the impacts to spotted owl prey species both temporally and spatially within the action areas, providing areas for spotted owl foraging during project implementation. Of the 135,765 total acres in the combined action areas, 96 percent (129,715 acres) of spotted owl habitat will remain untreated by the proposed action. Specific to each action area, 96 and 83 percent (Bear Grub and Round Oak of NRF habitat will remain untreated. Therefore, much of the action areas will provide current levels of prey species and foraging opportunities for spotted owls, which could alleviate the pressure placed on habitats by barred owls. At least two timber sales within the proposed projects would be implemented in 2020 (Assessment, pp. 37), but on-the-ground activities are likely to be conducted over a longer time period- as discussed above. The results of distributing effects spatially and temporally could reduce the impact of short-term negative impacts at the project level. Residual trees, snags, and down wood that are retained in the thinned stands would provide some cover for spotted owl prey species over time, and would help minimize harvest impacts to some prey species. Harvest activities may reduce flying squirrel densities in treated stands, but those same activities have the potential to be beneficial for

woodrats and other small mammals (as summarized in Courtney et al. 2004, Verschuyl et al. 2011, p. 227, and Sollmann et al. 2016 p. 104-105).

Considering all of the available information, the Service anticipates both short and long-term reductions in the distribution and abundance of primary prey species of the spotted owl, in particular the northern flying squirrel in the action areas caused by the habitat modification treatments (i.e., removal and downgrade and to some extent modify). These negative impacts to the prey base may be offset in the long-term by the on-site retention of snags and coarse wood as described in the Description of the Proposed Action and for the spatial and temporal implementation aspects as describe immediately above.

**Competition between Spotted Owls and Barred Owls**

Competition with established populations of barred owls has emerged as a much more prominent and complex threat to the long-term persistence of the spotted owl than was anticipated since the listing of the spotted owl, earlier versions of draft Recovery Plans and during the development and adoption of the NWFP. Subsequently, the pressing threat of the barred owl has been factored into the Revised Northern Spotted Owl Recovery Plan (USDI FWS 2011), Spotted Owl Critical Habitat designation (USDI FWS 2012), development of a barred owl experimental removal plan (USDI FWS 2013), revisions to BLM RMPs (USDI BLM 2016) and the Service's Biological Opinion on the BLM's RMP (USDI FWS 2016).

Available evidence suggests that the presence and distribution of barred owls may affect habitat quality for (and use by) spotted owls (Wiens 2012 and Yackulic et al. 2012, Yackulic et al. 2019, Wiens et al. 2014; Dugger et al. 2016, Wiens et al. 2017). Additionally, many studies suggest that the two species compete for resources and that maintaining older, high quality forest habitat may help spotted owls persist, at least in the short-term (see Threats in Appendix A). To date, there is no information describing forest conditions that provide spotted owls with a competitive advantage over barred owls. It is also not known if NRF habitat removal or thinning directly results in a range expansion of barred owls (USDI FWS 2013); however, at the landscape-scale, we assume that reductions in available habitat can result in the shifting of use areas of either species (Wiens et al. 2014). The degree of change in the availability and distribution of habitat in a landscape would likely influence these potential movements.

<u>Habitat and Prey Use</u>

Competition between barred owls and spotted owls is commonly referred to as interference competition. While barred owls utilize similar resources as spotted owls, they are considered generalist predators and consume a wider variety of food than spotted owls. Thus, barred owls are able to occupy habitat in much higher densities than spotted owls. This packing effect is likely to negatively affect the food supply of the remaining spotted owls. The competition for food and the aggressive nature of barred owls may explain why spotted owls are less likely to remain in their territories in the presence of barred owls. Strong effects of barred owls on spotted owls (e.g., occupancy, survival, reproduction, population size, etc) is now firmly described in the literature (Bailey et al. 2009, Dugger 2016, Dugger et al. 2011, Kelly et al. 2003, Kroll et al. 2010, Olson et al. 2005, Sovern et al. 2014; Yackulic et al. 2014, Yackulic et al.

2019, Anthony et al. 2006, Diller et al. 2016, Dugger et al. 2016, Forsman et al. 2011, and Glenn et al. 2011).

In addition to the competition for food, barred owls occupy and use a broader range of forest types in the Pacific Northwest (Livezey 2007), including fragmented mixed-deciduous forest in rural and urban landscapes (Rullman and Marzluff 2014), older forest in the northern Cascades (Hamer et al. 2007) and lower elevations (Hamer et al. 2007). In the Oregon Coast Range, foraging barred owls most often used patches of old (>120 years) conifer forest in addition to riparian-hardwood forests in relatively flat areas (Wiens et al. 2014). In the redwood region of coastal California, barred owls most often used sites with greater understory vegetation height and more hardwood trees, perhaps in response to greater densities of woodrats (*Neotoma* spp.) in these conditions (Weisel 2015). In Olympic National Park, Gremel (2005) found that spotted owls were moving to higher elevations and steeper slopes, possibly in response to barred owls. In Mt. Rainier National Park, Mangan et al. (2019) found that mean slope of territories was positively associated with spotted owl occupancy dynamics. That is, observed occupancy by spotted owls increased at territories with higher slopes in response to the increased presence of barred owls. This finding suggests that habitat partitioning was occurring between the species, similar to other observations of barred owl habitat preferences in the Pacific Northwest (i.e. mesic, low-elevation, low-slope sites; Singleton et al. 2010, Wiens et al. 2014). Despite the contiguity and age of the forest landscape in the Mt. Rainier study area, authors found no relationship between habitat variables and northern spotted owl occupancy dynamics, suggesting that barred owl presence was a primary influence in spotted owl occupancy rates (Mangan et al. pp. 11-14). The forest-landscape in the Mt. Rainier study area is dominated by old growth forest, where timber harvest and fire has not occurred.

Collectively, these studies are consistent with other studies which have indicated that barred owls use a broader range of forest types than those used by spotted owls. Barred owl use of older forest in combination with moist, valley-bottom forest was consistent with forest associations described for barred owl nesting areas (Buchanan et al. 2004, Herter and Hicks 2000, Pearson and Livezey 2003). However, these findings show abiotic (e.g., slope, aspect, elevation) differences in habitat selection, which are factors that cannot necessarily be managed to benefit spotted owls. Systematic studies have yet to quantify the full range of forest conditions that support barred owls in the Pacific Northwest. Comparing fine scale habitat use of barred owls and spotted owls, Jenkins et al. (2019) found that while both species used forested areas with tall canopy more often than areas with low canopy, spotted owls were more commonly found in areas with lower overstory tree cover, more developed understory, and steeper slopes. This is the first evidence of fine-scale partitioning based on structural forest properties by northern spotted owls and barred owls. However, potential management actions that could be conducted to reflect the findings of Jenkins et al. (2019) would likely still be detrimental to spotted owls, such as reducing canopy cover and creating conditions for a more developed understory. Specific management actions that would benefit spotted owls more than barred owls is not fully understood.

<u>Dispersal and Connectivity</u>
As Lesmeister et al. (2018) indicate, it is unknown how barred owls influence juvenile spotted owl survival or dispersal. Historically, adult spotted owls exhibited strong nesting-site and mate

fidelity, with fewer than 8 percent of individuals dispersing to a different territory between years (Forsman et al. 1984, 2002). In recent years, however, field observations suggest that inter-territory movements by resident spotted owls are increasing, and that such movements appear to coincide with the colonization of barred owls (Dugger et al. 2011, Dugger et al. 2016 and Olson et al. 2005). Additional research is needed that addresses how forest alteration influences barred owl and spotted owl interactions, subadult and adult movements, as well as to better understand which forest management practices would benefit spotted owls.

Population

Interspecific competition between spotted owls and barred owls is causing population declines of spotted owls (Dugger et al. 2016, Wiens et al. 2020). Competitive pressure from barred owls may negate the benefits of recruitment of suitable forest cover, because barred owls exclude spotted owls from sites that otherwise are suitable for spotted owls and as a result would negatively affect site occupancy, reproduction and survival (Mangan et al. 2019).

Removal studies have demonstrated a positive association between removal of barred owls and population trends of spotted owls; these responses appear to vary between study areas (Diller et al. 2016, Dugger et al. 2016, Wiens et al. 2020); effectiveness may be influenced by the timing of the management relative to the timing of the barred owl invasion (Wood et al. 2020). Modeling studies have also shown beneficial effects of barred owl removal for spotted owls (Dunk et al. 2019, USDI BLM 2016). Some populations of spotted owls have responded positively to the removal of barred owls during the removal experiments; supporting the hypothesis that along with forest conservation and management, removal of barred owls might slow or reverse local declines in spotted owl populations in some areas (Holm 2016, Diller et al. 2016, Dugger et al. 2016). Dunk et al. 2019 (p. 38) suggested that barred owl populations within the range of the spotted owl are apparently not currently at equilibrium. Thus, barred owl impacts, in many portions of the spotted owl's range will increase if no countervailing management actions are taken. For example, under the no barred owl control scenario, state-wide spotted owl populations declined by 95 percent, but under the barred owl control scenario, spotted owl populations decline by about 50 percent. The long-term effectiveness of removal is currently being evaluated in the barred owl removal experiment (USDI FWS 2013, Wiens et al. 2020). Projections from occupancy models suggest that maintaining barred owls at a relatively low occupancy level (0.2/survey polygon) may decrease competition and benefit northern spotted owls by significantly lowering barred owl colonization rates (Yackulic et al. 2014).

It remains uncertain how, or if, spotted owls can coexist with barred owls (see Gutierrez et al. 2007). The long-term effects to spotted owls from barred owls and the overall partition of resources remain unknown, and studies are needed to identify resilient sites for spotted owls in the face of competitive interactions with barred owls, if they exist. Overall, best available evidence suggests that a combination of habitat protection and active management of barred owls are the two highest priorities for stabilizing declining trends in populations of spotted owls.

Forest Management Considerations

Ameliorating the potential negative effects of barred owl competition is an essential component of the recovery of the northern spotted owl. Removal of barred owls is a tool toward spotted owl

recovery and further discussed below. The degree to which the colonizing population of barred owls has reached carrying capacity within the geographic range of the spotted owl is currently unknown and may not be at equilibrium (Dunk et al. 2019), but studies are underway that can help address this uncertainty (e.g., Wiens et al. 2017, Wiens et al. 2020). Barred owl populations may continue to increase depending on the capacity of available habitat and food resources, which varies regionally with forest composition and latitudinal changes in prey communities and climate.

In examining forest or habitat management that may favor spotted owls and hinder barred owls, the following factors should be considered:

- To date, there are no known information that there are forest conditions under which spotted owls have a competitive advantage over barred owl and that we can manage for these conditions.
- To date, studies suggest barred owls use a broad range of habitat conditions including all types of habitat used by spotted owls.
- Managing habitat to be favorable and beneficial to spotted owls and simultaneously unfavorable to barred owls is not understood would require a very long time to test, with limited potential for success.
- During the time needed to implement and evaluate effects of forest management on spotted owls where they co-exist with barred owls, barred owl populations would continue to increase and expand.
- Changes in the abundance and distribution of an apex predator like the barred owl can have cascading effects on prey populations and food web dynamics (Holm et al. 2016, Wiens et al. 2014), as well as populations of other small sympatric owls (Acker 2012, Elliot 2006).
- Differences in space use, abundance, demography, suitable forest, diets, and behavior collectively suggest that the barred owl is not a direct functional replacement of the spotted owl in old-growth forest ecosystems (Holm et al. 2016, Wiens et al. 2014). As a consequence, additional changes in community structure and ecosystem processes are anticipated as a result of barred owl encroachment into areas managed under Federal Forest Management Plans.

In the 2011 Revised Recovery Plan for the Northern Spotted Owl, the Service's modeling team used the HexSim modeling program (Schumaker 2008) to simulate population-level responses to various conservation strategies and other threats (USDI FWS 2011). This work provided further evidence that the framework, standards, and guidelines of the interagency Northwest Forest Plan (NWFP) are critical components to spotted owl recovery plans, but the impacts of barred owls will likely need to be controlled if spotted owl species recovery is to be successful (Dunk et al. 2019).

Similar to the recovery planning used by the Service, Marcot et al. (2013) also used the HexSim model to evaluate how size and spacing of suitable forest cover types for spotted owls affected simulated population size and persistence. Their results indicated that long-term occupancy rates were significantly higher with suitable forest patches large enough to support 25 spotted owl pairs or more, with less than 9.3 mi (15 km) spacing between patches, and with overall

landscapes of at least 35 to 40 percent suitable forest cover types for nesting and roosting (i.e., analogous to contemporary conservation planning for spotted owls). The Service's work above and Marcot et al. (2013) used static habitat maps that did not incorporate climate change or wildfire impacts on spotted owls. Only the USFWS (2011b) model incorporated effects of barred owls.

As part of the analysis for the BLM's RMP FEIS and section 7 consultation, BLM developed a modeling strategy and analytical approach to assess the influence of BLM lands in western Oregon on northern spotted owl demography (USDI BLM 2016 pp. 928-989). The modeling approach included a "habitat model" (MaxEnt [same as used in the Service's Recovery Plan – Appendix C]) informed by a forest development and harvest selection model (Organon and Woodstock, respectively) and a population response model (Hexsim [same as used in the Service's Recovery Plan – Appendix C]) that included a barred owl effect and also wildfire disturbance.

The BLM included a "No Harvest" scenario, where all forest capable lands were allowed to develop without intervention in the analysis along with alternatives that removed differing amounts of older forest associated with use by spotted owls within the Harvest Land Base. This allowed them to assess the likelihood that conservations needs associated with habitat could be met through the reserve networks under each alternative. The FEIS analysis showed that there were minimal differences in the formation of large blocks of spotted owl habitat or expected population responses between the No Harvest Scenario and the Preferred Alternative (See USDI BLM 2016 Figures 3-180 and 182, pp. 938 and 940, and Figure 3-188, p. 959 respectively). Forest cover amount on BLM managed lands had essentially no influence on projected spotted owl population trends due to the effects of barred owls.

While BLM's analysis showed that no amount BLM forest reserved from harvest would result in positive northern spotted owl population response when barred owls are present, it did recognize that importance of limiting the direct effects to extant spotted owls from harvest activities. This would ensure that any additional stressors on the spotted owl population were minimized and survival is supported. Consistent with guidance from the Service's Spotted Owl Recovery Plan to minimize short term impacts to extant spotted owls; the BLM adopted a provision under the RMP that it would not authorize the incidental take of spotted owls from timber harvest until a barred owl management program has begun (USDI BLM 2016 pp. xxxiii, 87). If after, a maximum of 8 years (prior to 2024) from the implementation of the RMP, a barred owl plan meeting the assumptions in the FEIS and PRMP Biological Opinion (BO) had not begun, BLM and the Service would reinitiate consultation.

Although the RMP will remove forest cover associated with use by northern spotted owls, management actions will avoid the potential for take. The RMP BO found that the expected amount of habitat modifications was not expected to appreciably reduce the survival or recovery of the spotted owl because spotted owl habitat availability in the RMP action area was not likely to limit the reproduction, numbers, and distribution of the spotted owl (USDI FWS 2016, Biological Opinion, p. 620)

Project Level Consultation

Based on best available evidence (see APPENDIX A – Status of the Species), the Service considers competition from the barred owl to pose the most significant and pressing threat to the continued existence of the northern spotted owl. Our evaluation herein focuses on whether the proposed action, Bear Grub and Round Oak, could potentially exacerbate competitive interactions between the two species by reducing the availability of NRF habitat (see Recovery Plan section below), if the two species co-occur in the action area.

The proposed action includes the removal and downgrade of spotted owl NRF habitat; however, 96 and 83 percent of the NRF habitat in the Bear Grub and Round Oak action areas, respectively will not be impacted by the proposed actions. As indicated above, competition from barred owls may cause shifts and movements in spotted owls. The extent of NRF habitat in the action areas that will not be impacted by the proposed action is likely to accommodate shifting and re-colonization of spotted owls on the landscape, albeit depending on the extent of the barred owl influence of the habitat. But as described elsewhere herein, (e.g., Table 10) barred owls already occupy many of the known spotted owl sites. Of the currently occupied sites under the proposed action, sites 2220O and 3561B, associated with the Round Oak project, neither of these two sites have barred owl detections (Table 10); however, barred owl specific surveys have not been conducted so barred owls could be present. The proposed action does not include any removal or downgrade of NRF habitat at these two sites, except for less than 1 acre of removal at site 3561B (Table 16). As a result, we do not anticipate the Round Oak project to exacerbate the competitive interactions between the species for these occupied sites.

The intent of Recovery Action 32 is to conserve the older and more structurally complex multi-layered conifer forests on federal lands in order to not further exacerbate the competitive interactions between spotted owls and barred owls. To the extent practicable, mapped structurally complex forest is being retained under the proposed action (Table 19). Further, the LSR system is intended to provide for recovery of spotted owls even with barred owls on the landscape. As provided herein, 70 percent of the overall proposed action is planned within the HLB (Table 2) (less than 5 percent in LSR), which is targeted for timber harvest under the RMP. To some extent, these species are co-occurring in the action areas (Table 10) so we anticipate that competitive interactions between the two species are occurring and are likely to continue; the overall outcome of this relationship as a result of the proposed action is uncertain. Because barred owls may compete with spotted owls and may exclude them from substantial amounts of otherwise useable habitat, securing habitat alone is likely not sufficient for spotted owl recovery. As described below and in the analysis supporting the BLM's RMP, while habitat is being conserved for spotted owls under the RMP and through discretionary recovery actions, removal of barred owls is likely needed to recovery spotted owls.

The proposed projects, Bear Grub and Round Oak, are within the Medford District BLM Sustained Yield Unit and primarily occurs within the MITA/LITA/UTA Land Use Allocation(s). As discussed in the Project Objectives and Development Strategies section above, the proposed actions are consistent with the management direction and assumptions on harvest rate in the RMP and extent the Service considered in the Biological Opinion for the RMP.

The Service's opinion of No Jeopardy relied on:

a) no incidental take of spotted owls to minimize effects to spotted owl survival until a barred owl management plan meeting Biological Opinion assumptions was in place,
b) a time limit forcing reinitiation if a management plan isn't put in place.
c) when and if incidental take was allowable, it would be limited to a specified proportion of the population, and;
d) sufficient area and distribution of forested area reserved from sustained yield harvest to protect the majority of existing habitat and allow development of additional habitat to support population persistence and expansion.

As discussed in the Take Avoidance section herein, the proposed action would not result in incidental take of northern spotted owl. Barred owls and spotted owls co-occur on the Action Area and likely compete for resources. It is uncertain how the proposed action will exacerbate the competitive interaction of the species. However, for the currently occupied sites as described above, removal and downgrade of habitat is not planned at the occupied sites, so any further exacerbations to spotted owls from the proposed action is not anticipated and NRF habitat is available to accommodate spotted owls that may shift home ranges. The rate, type, and area of proposed harvest are consistent with the assumptions in the RMP BO and would not delay or preclude the development of NR structure within the reserve LSR. In Environmental Baseline section, the impacts from wildfire have been included and serve as basis for the Effects to Habitat analysis.

The Service's Opinion that implementing the RMP would not result in Destruction or Adverse Modification of Critical Habitat is based on:

a) approximately 79 percent of Critical Habitat managed by BLM is in reserve LUA where management would be consistent with Critical Habitat and Recovery guidelines.
b) Approximately 18 percent is in the HLB, but based on expected harvest rate compared to development in the LSR, there is expected to be a net increase in NR habitat within Critical Habitat Units.

As discussed in detail in the Effect to Critical Habitat section herein, the proposed action would adversely affect PBFs in critical habitat subunit KLE-3, KLE-5 and KLE-6. However, the rate, type and area of proposed harvest are consistent with the assumptions in the RMP BO. All NR stands in LSR critical habitat would be maintained. In the Environmental Baseline section, it is updated to reflect the recent wildfires within critical habitat and analyzed herein.

Due to reductions of timber harvest on federal lands since the late 1980s, forests throughout most of the range of the spotted owl are on a trajectory— through succession—to develop suitable forest characteristics for spotted owls in coming decades (see Davis et al. 2016). When the NWFP was adopted, and more recently the RMP on BLM lands, spotted owl populations were expected to continue declining for several decades because of lingering impacts of previous losses of suitable forest cover, yet the magnitude and characteristics of barred owl impacts were unknown and unexpected at that time (of the NWFP). Currently, successful spotted owl recovery rests on improving our understanding of how to minimize impacts of barred owls, and on fine-tuning our ability to retain needed forest structure while also increasing resiliency of forests through strategic management. Coupling barred owl removal with management actions

that promote quality spotted owl habitat reflect the 2-pronged approach necessary to ensure the persistence of the northern spotted owl (Diller et al. 2016, Dugger et al. 2016, Holm 2016, Dunk et al. 2019, Long and Wolfe 2019, and Wood et al. 2020). However, additional protection of habitat while barred owls are on the landscape, as modeled for various landscape level conservation efforts for spotted owls, do not improve the situation for spotted owls, unless barred owls are reduced.

**Disturbance**

Project Design Criteria restricting activities during the breeding season and within recommended disturbance distance thresholds will be incorporated into the Bear Grub and Round Oak Projects (Appendix B). Applying the Mandatory PDC should avoid noise or activity which would adversely affect nesting owls and their young. On-the ground implementation will not occur during the critical breeding season (March 1 to July 15). Nesting owls are confined to an area close to the nest, but once the young fledge, they can move away from noise and activities that might cause adverse effects.

**Summary**

The primary objectives of the District's FY20 Batch of Projects are to meet the District ASQ, and secondarily create more resilient forest-structural and vegetative conditions to a more natural range in some stands, and reduce fire risk and insect and disease outbreaks, and stand susceptibility to disturbance (Assessment, pp. 12-14). The Service recognizes that impacts to spotted owl habitats may be necessary to maximize treatment efficacy. The rate of habitat loss from uncharacteristic fires in the dry forest provinces, particularly the Klamath Province, is indicative of a threat which needs to be addressed. Increasing the intensity of treatments and focusing treatments in vegetation types associated with frequent fire regimes, (i.e., active management) is likely to result in lower crown fire potential, thus increasing the affected stand's potential for withstanding disturbance under characteristic fire conditions. As provide above and per Appendix D best available information suggests that active management can influence and benefit stand trajectories and reduce fire risk and behavior.

Lesmeister et al. (2019b) concluded that older mixed conifer forests are less susceptible to high-severity fire than other successional stages, even under high fire weather conditions, but notes that habitat suitability is reduced or lost when they do burn at moderate and high severity. The 2011 Revised Recovery Plan addresses this concern and recommends conserving older more structurally complex habitat and strategically treating around older forest habitat. The Recovery Plan further recommends active management that includes the strategic placement of projects guided by a landscape context where practicable. The proposed action includes protection of structurally complex forest through LSR protections and proposes active management to portions of the HLB.

Spotted owls at 37 sites are likely to be adversely affected by the proposed action; however, the action will not result of incidental take of spotted owls and as directed by RMP management direction. The District is further conserving spotted owls through the RMP incorporation of discretionary recommendations 6, 10, and 32 of the Recovery Plan (Assessment, p. 51). By

implementing these recovery actions, the District is collectively helping to address primary and secondary threats to the spotted owl, which is competition from barred owls and habitat loss due to timber harvest and wildfires (USDI FWS 2016, p. 583). Dispersal connectivity is expected to continue to fill its role for spotted owl transient dispersal. As a result of these actions, the demographic role of the action areas are expected to provide for spotted owl survival and reproduction. Collectively for these reasons, the Service anticipates that the District's FY20 Batch of Projects action areas will continue to provide for spotted owl survival and recovery.

**Spotted Owl Conservation and Late-successional Reserves**

While only a limited amount of the proposed action occurs in the late-successional reserves, it is worth noting the role of the reserves in this consultation.

Large, contiguous blocks of late-successional forest have been an element of northern spotted owl conservation strategies for over two decades. For example, Thomas et al. (1990, pp. 23–27) and reaffirmed by Courtney et al. (2004, pp. 9-11, 9-15) 15 years later described that a conservation strategy for the northern spotted owl requires large blocks of nesting, roosting, and foraging habitat that support clusters of reproducing owls, distributed across a variety of ecological conditions and spaced so as to facilitate owl movement between the blocks. More recently, the Service's Revised Recovery Plan for the Northern Spotted Owl recommends managing for large, contiguous blocks of late-successional forest (USDI FWS 2011, p. III-19) (see USDI BLM 2016a p. 7). For example, in the 2011 Revised Recovery Plan for the Northern Spotted Owl, the Service's modeling team used the HexSim modeling program (Schumaker 2008) to simulate population-level responses to various conservation strategies and other threats (USDI FWS 2011). This work provided further evidence that the framework, standards, and guidelines of the interagency Northwest Forest Plan (NWFP) are critical components to spotted owl recovery plans, but the impacts of barred owls will likely need to be controlled if spotted owl species recovery is to be successful (Dunk et al. 2019). The resulting models were used for delineation and designation of what was considered critical habitat (USFWS 2011b).

Similar to the recovery planning used by the Service, Marcot et al. (2013) also used the HexSim model to evaluate how size and spacing of suitable forest cover types for spotted owls affected simulated population size and persistence. Their results indicated that long-term occupancy rates were significantly higher with suitable forest patches large enough to support 25 spotted owl pairs or more, with less than 9.3 mi (15 km) spacing between patches, and with overall landscapes of at least 35 to 40 percent suitable forest cover types for nesting and roosting (i.e., analogous to contemporary conservation planning for spotted owls).

As part of the analysis for the BLM's RMP FEIS and section 7 consultation, BLM developed a modeling strategy and analytical approach to assess the influence of BLM lands in western Oregon on northern spotted owl demography (USDI BLM 2016 pp. 928-989). The modeling approach included a "habitat model" (MaxEnt [same as used in the Service's Recovery Plan – Appendix C]) informed by a forest development and harvest selection model (Organon and Woodstock, respectively) and a population response model (Hexsim [same as used in the Service's Recovery Plan – Appendix C]) that included a barred owl effect and also wildfire disturbance (see below for BLM wildfire modeling).

"The ability of the BLM to contribute to the conservation and recovery of the northern spotted owl necessitates maintaining a network of large blocks of forest to be managed for late-successional forests (USDI BLM 2016a p. 7)".

BLM's Management Direction and Objectives in the LSRs include:
"Contribute to the conservation and recovery of threatened and endangered species, including—

- Maintaining a network of large blocks of forest to be managed for late-successional forests; and,
- Maintaining older and more structurally-complex multi-layered conifer forests;" (USDI BLM 2016a p. xxiii, USDI BLM 2016b p. 1).

In developing the BLM's resource management plans, BLM assembled a team of northern spotted owl experts, fire ecologists, silviculturists, and modelers to develop an approach to model and analyze the potential effects on northern spotted owl habitat and populations from large wildfires (USDI BLM 2016, RMP Vol. 3, Appendix D). For this analysis, the BLM predicted future wildfire effects based upon historic fire frequency, size, and severity. This effort also supported the Service's request for the BLM to evaluate whether the resulting plan would provide sufficient habitat to assure persistence of the northern spotted owl for the next 50 years. This estimation of the quantity of habitat affected by fire over the next five decades better informs the development of land management strategies for the BLM-administered lands in western Oregon.

Although the relationship between large wildfire frequency and severity on owl demography is not fully understood, the BLM used the underlying data for the maps produced from this modeling effort as input into the vegetation modeling process to inform the effects of disturbance on habitat loss and recruitment over the next 5 decades. The BLM used the results of the vegetation modeling efforts in the northern spotted owl population analysis for these RMP revisions, which will inform management decisions on lands administered by the BLM in western Oregon.

Wildfire is a natural process within the identified range for the northern spotted owl, especially in the southern and eastern portions of the range. While the spotted owl has adapted to wildfire and its effects in an intact landscape, human development and land use have reduced and fragmented habitat and populations in large portions of the region (Davis and Lint 2005, Davis *et al*. 2011). One result has been an increase in the potential for adverse effects of large, high severity wildfires on remnant northern spotted owl habitats and populations. Over the last two decades, the rates of habitat loss from high severity fires have disproportionately affected the Oregon and California portions of the Klamath Physiographic Province, particularly with respect to reserve system across Federal lands (BLM [while under the NWFP] and Forest Service) (Davis et al., 2011, p. iii; Davis et al. 2016, pp 23, 35-38). This is relevant because Medford District BLM lands, location of the Bear Grub and Round Oak action areas, occur within portions of the Oregon Klamath province. The overall expectation of the NWFP and BLM's 2016 RMP is that LSRs, currently or eventually, would achieve habitat conditions to support multiple breeding pairs and collectively would facilitate spotted owl population recovery (see the conservation and habitat modeling above). The success of meeting that threshold depends on the

frequency, severity, and spatial extent of disturbance (e.g., wildfire, timber harvests), as well as the rate of forest succession, and interactions among these processes on forest recruitment.

Results from long-term monitoring (see Davis et al. 2016) indicate that during the first two decades of the NWFP, range-wide losses of nesting/roosting habitat on federal lands were estimated at 5.2 percent (474,300 ac) from wildfire; 1.3 percent (116,100 ac) from timber harvesting; and 0.7 percent (59,800 ac) from insects, disease, or other natural disturbances. This accounted for a total range-wide loss of 7.2 percent, but we estimated an overall net decrease of 1.5 percent, owing to new nesting/roosting habitat recruitment. Range-wide, the observed rate of habitat loss on federal lands was less than what was anticipated when the NWFP was designed, mostly as a result of less timber harvesting than was anticipated. Losses from wildfire were slightly higher than anticipated in federal reserved LUAs at the range scale. Insects and disease accounted for less than 1 percent of losses. While dispersal habitat has shown a net increase of 2.2 percent on federal lands, dispersal-capable landscapes have been reduced in area by 5 percent, partially owing to losses of habitat on surrounding nonfederal lands but also owing to large wildfires on federal lands.

Forest cover trends on federal lands during the next two to three decades are expected to benefit spotted owls because significant recruitment of suitable nesting/roosting forest cover is expected to offset many pre-NWFP losses (Davis et al. 2016). However, this expectation is based on current rates of harvest and wildfire occurrence on federal lands, which may change depending on future forest plan revisions and the predicted increased spatial extent, frequency, and severity of wildfires due to climate change. In addition, competitive pressure from established barred owls (as discussed elsewhere herein) has raised uncertainties about whether recruitment of suitable forest cover will be enough to conserve spotted owls over the long term. If spotted owls are to persist in LSRs under competitive pressure from barred owls, barred owl removal is likely needed.

Spotted owl nesting/roosting habitat was projected to continue to decline for up to 50 years or until about 2044 (USDA and USDI 1994, chap. 3 and 4, pg. 228) (and under the BLM RMP). Eventually, habitat recruitment was expected to exceed losses and nesting/roosting habitat within the LSR network would begin to increase and become less fragmented, providing greater benefits for spotted owls as well as other late-successional forest species (USDA and USDI 1994, apps. J3-8). With foresight, the LSRs within fire-prone provinces were designed with wildfire in mind. Late-successional reserves were delineated to be large enough to withstand large wildfire events over 50 years such that unburned portions would maintain a well-connected network of nesting/roosting and dispersal habitat (USDA and USDI 1994, app. J3-8 and 9). However, this design feature may be challenged in the near future.

The recovery of future spotted owl habitat may be affected by climate change that could alter the pattern and frequency of large wildfire within the northern spotted owl's range. Climate change is also expected to alter forest species composition within the Pacific Northwest by the end of the 21st century (Peterson et al. 2014). Subalpine forests are expected to recede in area while pine-dominated forests will likely expand. Both of these forest types are normally not used for nesting and roosting by spotted owls, and these potential changes will affect amounts and distribution of future spotted owl habitat. While any changes in forest species composition over two decades

were most likely due to disturbances (e.g., wildfire, timber harvest, etc.) or natural succession, the potential for forest species composition changes resulting from changes in climate will need to be considered in future monitoring (Davis et al. 2016, p. 37). Carroll et al. (2010) used a climatic niche modeling approach to evaluate the regional system of LSRs for resiliency to climate change for providing necessary resources of species associated with old forest. The LSRs functioned better than expected by chance for capturing all of the species, but community composition and interspecific interactions were also important to consider in evaluating effectiveness of the reserves. As such, a fixed reserved system needs to provide for topographic heterogeneity (i.e., designed for resilience) to have an increased likelihood of retaining the biological diversity of old-forest ecosystems under climate change. Continued monitoring is needed to adaptively manage under a changing climate.

One of the goals of the NWFP and more recently with the BLM RMP, was to protect and enhance habitat for the spotted owls on federal lands. The first step in achieving this goal was to reduce the rate at which habitat was being lost. Monitoring shows that the NWFP has been effective at achieving this. Eventually, the NWFP (and under the BLM RMP) anticipated restoration of habitat within the large reserve network over the course of several decades; recruitment of habitat is currently occurring in portions of the range and beginning to help offset losses (Davis et al. 2016).

## EFFECTS TO SPOTTED OWL CRITICAL HABITAT

This section evaluates how the proposed action is likely to affect the capability of affected critical habitat PBFs to support spotted owl life history requirements regardless of the species' presence or absence in the affected critical habitat (77 FR 233:71876-72068). We also evaluate how the impacts of the action may likely influence the designated functions of critical habitat at the landscape, subunit and unit scale. As described in the final rule (p.71938) five possible outcomes in terms of how proposed Federal actions may affect the PBFs of northern spotted owl critical habitat or essential habitat qualities associated with that critical habitat area: (1) No effect; (2) wholly beneficial effects (e.g., improve habitat condition); (3) both short-term adverse effects and long-term beneficial effects; (4) insignificant or discountable adverse effects; or (5) wholly adverse effects.

The designation of areas as critical habitat does not change land use allocations or management direction under the BLM's RMP, or other land management plans, nor does the critical habitat rule establish any management plan or prescriptions for the management of critical habitat. However, the Service encourages land managers to consider implementation of forest management practices recommended in the Revised Recovery Plan to restore natural ecological processes where they have been disrupted or suppressed (*e.g.,*natural fire regimes), and application of ''ecological forestry'' management practices (e.g., Gustafsson *et al.* 2012, entire; Franklin *et al.* 2007, entire; Kuuluvainen and Grenfell *et al.* 2012 entire) within critical habitat to reduce the potential for adverse impacts associated with commercial timber harvest when such harvest is planned within or adjacent to critical habitat. In sum, the Service encourages land managers to consider the conservation of existing high-quality northern spotted owl habitat, the restoration of forest ecosystem health, and the ecological forestry management practices

recommended in the Revised Recovery Plan that are compatible with both the goals of northern spotted owl recovery and management direction of land use plans such as the RMP (USDI FWS 2012b:71877).

The District's FY20 Batch of Projects collectively will affect up to 2,178 acres of spotted owl critical habitat in three different critical habitat sub-units. The primary impacts to critical habitat will be removal and downgrade of approximately 1,207 acres NR/F habitat (PBFs 2 and 3) (Table 18). Of the 1,207 acres of NRF habitat proposed for removal and downgrade, 47 percent (572 acres) are in nesting roosting habitat (PBF 2) and 53 percent (640 acres) in foraging habitat (PBF 3). The foraging stands may have large trees and high canopy cover, but they are often dense, uniform and single story, lacking habitat components such as layering, diameter distributions, snags and coarse woody debris. Approximately 585 acres of NR/F and dispersal-only critical habitat are proposed for thinning that will maintain the current function of habitat.

Overall, the proposed action would lead to a 0.01 (KLE-3), 5 (KLE-5), and 0.6 (KLE-6) percent reduction of the NRF (PBFs 2 and 3) habitat baseline (Table 18).

**Removal and Downgrade of PBFs #2 and #3**

The primary objective for the 1,156 acres of NR and F proposed for removal within critical habitat is to meet SWO RMP/ROD directed timber ASQ volume targets on the Harvest Land Base LUA. These acres habitat proposed for removal in the Bear Grub and Round Oak projects would not be expected to obtain NRF conditions in designated critical habitat for decades. The Biological Opinion for the BLM Western Oregon Resource Management Plan predicted that uneven-aged management would result in the loss of PBFs #2 and #3. However, even with the proposed loss, the prescriptions would promote more rapid development of stands containing the elements associated with nesting-roosting habitat and would promote restoration of natural disturbance regimes, compared to regeneration type treatments. The Service also concluded that these losses would be mitigated because during this same time span that these the critical habitat in reserved LUAs are expected to develop spotted owl habitat through ingrowth and through management actions such as thinnings designed to speed the development of critical habitat PBFs (USDI FWS 2016, pp. 690 and 691).

Up to six of the 1,156 acres of NRF/F proposed for removal are due to road and landing construction. The road and landing construction would remove all vegetation and key habitat components (layering, large trees, snags, coarse woody debris, and high canopy cover) and are not expected to return to or obtain NRF/F functioning habitat as long as these areas are utilized as roads or landings in the future.

Effects to spotted owl critical habitat PBFs through their removal are similar to the effects of NRF removal as discussed in the Effects to Habitat section above and therefore will not be repeated here but in general include the removal of large diameter trees, reduced layering and a reduction in canopy cover etc.

**KLE-3** – Within KLE-3 (Bear Grub) 0 acres of NRF habitat is proposed for removal. This would not result in a change at the subunit scale (0 acres out of the 37,627 NRF acres of KLE-3 subunit).

**KLE-5** – Within KLE-5 (Round Oak) up to 928 acres of NRF is proposed for removal. This represents a five percent change of NRF habitat at the subunit scale and would not result in an appreciable change at the subunit scale (928 acres per 18,233 NRF acres of KLE-5).

**KLE-6** – Within KLE-6 (Bear Grub) up to 228 acres of NRF is proposed for removal. This represents an approximately 0.5 percent change at the subunit scale (228 acres per 44,807 NRF acres of KLE-6). The amount of change is not expected to result in an appreciable difference at the subunit scale because 99 percent of the subunit is unaffected by the proposed action.

**Table 18. Effects to Spotted Owl Critical Habitat from the Bear Grub and Round Oak Proposed Actions, Medford District BLM FY20 Batch of Projects.**

| | NRF Removed (acres) | | NRF Downgrade (acres) | | NRF Modify (acres) | | Dispersal -Only Removed (acres) | Dispersal-Only Modify (acres) | Dispersal Quality Remove *(NRF+Dispersal-only)*[3] | Total Habitat Acres Treated |
|---|---|---|---|---|---|---|---|---|---|---|
| | NR[1] | F[2] | NR[1] | F[1] | NR[1] | F[2] | | | | |
| **KLE-3** (baseline acres from Table 11) | **37,627** | | | | | | ***43,696*** *(Dispersal-only)* | | **81,323** *(NRF + Dispersal-only)* | |
| **Bear Grub** | 0 | 0 | 0 | 5 | 0 | 0 | 103 | 21 | 103 | 129 |
| **% Change to KLE-3 Baseline Habitat** | No Change | | - 0.01 % | | No Change | | - 0.2 % | No Change | -0.1% | |
| **KLE-5** (baseline acres from Table 11) | **18,233** | | | | | | ***13,045*** *(Dispersal-only)* | | **38,252** *(NRF + Dispersal-only)* | |
| **Round Oak** | 525 | 403 | 0 | 0 | 21 | 65 | 34 | 55 | 962 | 1,103 |
| **% Change to KLE-5 Baseline Habitat** | - 5 % | | No Change | | No Change | | - 0.03 % | No Change | -2.5% | |
| **KLE-6** (baseline acres from Table 11) | **44,807** | | | | | | **88,136** *(Dispersal-only)* | | ***132,943*** *(NRF + Dispersal-only)* | |
| **Bear Grub** | 45 | 183 | 2 | 49 | 5 | 243 | 244 | 175 | 472 | 946 |
| **% Change to KLE-6 Baseline Habitat** | -0.5% | | -0.1% | | No Change | | - 0.3% | No Change | -0.4% | |

1- NRF = Nesting/Roosting/Foraging - PBF #2;
2- RF = Roosting /Foraging - PBF #3;
3- All Dispersal Baseline (Dispersal-only + NRF)

The proposed vegetation treatments in the Bear Grub Project would downgrade 2 acres of NR habitat (PBF #2) and 54 acres of foraging habitat (PBF #3) in designated critical habitat. There will be no NR or F downgrade in the Round Oak project. Treatments proposed to downgrade foraging habitat in the Bear Grub project are located in the LSR LUA. In these areas the treatments are silviculturally designed and intended to speed the trajectory of the development of spotted owl nesting habitat, improve resiliency, and restore ecological functions (USDI BLM 2016a, pp. 70, 72, and 74). These treatments would also help meet the District's non ASQ timber ASQ targets, which is a bi-product of the primary objective. By conducting these types of

treatments in PBF #3, over the long term, it is anticipated that stand resiliency would improve which would reduce fire risk and enhance the overall ecological condition of the stand and immediate landscape. These types of treatments were proposed in the Western Oregon Proposed Resource Management Plan/Final Environmental Statement (USDI BLM 2016b, p. 252) because the increased spatial heterogeneity at multiple scales, and disruption of fuel continuity, can alter potential fire behavior and may create conditions in which wildfire can occur without detrimental consequences, reducing impacts to highly valued resources, including timber and wildlife habitat (Finney 2001 and Jain et al. 2012). In stands that are not currently structurally-complex, the creation of small openings and heterogeneous (patchy) stand composition would move vegetation patterns and fuel loadings and arrangements toward conditions comparable to low- and mixed-severity fire regimes (Agee 2002). Additionally, in general, studies have shown that stands with higher fire resistance have reduced surface fuel loading, lower tree density, large diameter trees of fire-resistant species, increased height to live crown, and discontinuous horizontal and vertical fuels (USDI BLM 2016b, p. 243).

The current condition of the foraging stands proposed for treatment are generally either single-storied homogenous stands and lacking structure, or layered stands lacking the large diameter trees characteristic of supporting nesting habitat. Therefore, some long-term habitat benefits may also be achieved from the proposed action as tree diameter growth increases, multi-layered structure and species diversity develops. More immediate short-term impacts to spotted owls and critical habitat PBFs are anticipated due to the removal of key habitat features coincident with the likely use of the area by breeding spotted owls. According to the critical habitat rule, these tradeoffs of short-term impacts and longer-term habitat development are tradeoffs that are taken into consideration when designing dry forest restoration projects (USDI FWS 2012b, pp. 71881, 71942).

According to the 2012 Final Critical Habitat Rule (USDI FWS 2012b, pp.14062-14165), Section 7 consultations need to consider the temporal and spatial scale of impacts a proposed action may have on the PBFs. As part of the Rule, the Service recommends using a scale that is relevant to the needs and biology of the spotted owl and believes the 500-acre core-use area scale is a reasonable metric for land managers to use as a screen when assessing effects on critical habitat. The Rogue Basin Level 1 team has consistently used the 500-acre scale analysis in previous ESA Section 7 consultations. However, in this case, it was evident without doing a site specific 500-acre analysis that the amount of NRF removal and downgrade relative to the existing NRF at the 500-acre scale would be measureable. As a result, the District and the Service agree the removal of 1,156 acres of NRF habitat ***may affect, and would likely adversely affect*** (LAA) spotted owl critical habitat because it would result in a measurable removal of an essential physical or biological feature.

The removal and downgrade of NRF (PBF #2) and F (PBF #3) habitat ***may affect and would likely adversely*** affect spotted owl critical habitat.

**Effects from the Removal of Dispersal Quality Habitat** (NRF [PBFs #2 and #3] + Dispersal-only [PBF#4])
The Bear Grub and Round Oak Projects would remove 381 acres of dispersal-only habitat in designated critical habitat from vegetation treatments and road/ landing construction. The removal of 1,156 acres of NR and F habitat that also serves as dispersal quality habitat, when combined with the removal of dispersal-only habitat, would contribute to a reduction of dispersal habitat (PBF #4) in these critical habitat sub-units. The removal of dispersal-quality habitat in critical habitat ***may affect and likely adversely affect*** spotted owl critical habitat because it would result in a measurable removal of PBFs.

The removal of dispersal habitat (NRF + dispersal-only) would not affect the intended connectivity function of these sub-units (east/west and north/south connectivity). Habitat supporting the transience phase of dispersal contains stands with adequate tree size and canopy cover to provide minimal foraging opportunities and protection from avian predators. This may include younger and less diverse forest stands, such as even-aged, pole-sized stands, than foraging habitat but such stands should contain some roosting structures and foraging habitat to allow for temporary resting and feeding during the movement phase (USDI FWS 2011).

**Effects from NRF and Dispersal-Only Modify**
The proposed vegetation treatments in the Bear Grub and Round Oak Projects would modify, but maintain the function of 334 acres of NR and F habitat (PBFs # 2 and 3) and 251 acres of Dispersal-only habitat (PBFs # 1 and 4) in designated critical habitat. The District would follow the PDCs described above to ensure habitat would function post-treatment. As a result, no adverse effects are anticipated to critical habitat as a result of these treatments because the amount and condition of these PBFs would not change. Because PBFs are not anticipated to change as result of these treatments, connectivity and demographic support functions of the subunits are not expected to be altered.

**Effects to Capable Habitat**

Capable habitat is forests below the elevation limits of occupancy by territorial spotted owls, excluding serpentine soil areas that are capable of growing and sustaining structural conditions of spotted owl habitat (USDI BLM 2016a). Capable habitat is currently not spotted owl habitat but can become dispersal or NRF habitat in the future, as the trees mature and the canopy closes. Typically, capable habitat are young plantations.

Approximately 2,131 acres of early-seral (Capable) and Non-habitat will be treated (Table 3) and 329 acres of this total are in critical habitat. Of these 329 acres, only 17 acres (5 percent) are proposed for road and landing construction (all in Bear Grub and in KLE-6) which would preclude habitat development because of the potentially permanent nature of road and landing construction. These 17 acres are distributed throughout the Bear Grub action area (Assessment, p. 48). The proposed road and landing construction preventing the development of future spotted owl habitat would not be an appreciable change in the KLE-6 sub-unit, because no more than 0.05 percent of the current capable habitat would be affected.

The remaining 296 acres of capable habitat in Bear Grub and 16 acres in Round Oak are proposed for treatment with prescriptions that would not preclude the development of future spotted owl habitat. In some cases, the prescriptions would speed the trajectory of developing dispersal-only or nesting habitat in the next 20-30 years, consistent with Recovery Action 6.

**Effects to Critical Habitat Subunits KLE-3, KLE-5, KLE-6 (landscape level)**

Each of the subunits, KLE-3, KLE-5, and KLE-6, are expected to function as connectivity between subunits and units and demographic support to the overall population (USDI FWS 2012b). There are approximately 100, 40, and 80 historical spotted owl sites for each of the subunits, respectively (Assessment pp. 35).

Within the critical habitat subunits, the proposed action is removing dispersal-quality habitat which is anticipated to result in 0.1 to 2.5 percent of change to the spotted owl dispersal-quality habitat conditions within the subunits (Table18). This amount of removal, relative to the amount of acres remaining as spotted owl habitat post treatment (over 97 percent per subunit), is not expected to appreciable reduce the connectivity function within the subunits. Also from a landscape perspective, the watersheds of the action areas are expected to have sufficient habitat for dispersal function (see Habitat Effects section above). This is because habitat supporting the transience phase of dispersal contains stands with adequate tree size and canopy cover will remain post-harvest and provide minimal foraging opportunities and protection from avian predators. This may include younger and less diverse forest stands, such as even-aged, pole-sized stands, than foraging habitat but such stands should contain some roosting structures and foraging habitat to allow for temporary resting and feeding during the movement phase (USDI FWS 2011).

From a provincial perspective and prior to the 2018 fires, Davis et al. (2016 p. 28 and Figure 9 p. 33) concluded that the large (NWFP) reserve network (which overlaps large portions of critical habitat) remains mostly intact for dispersal, even with many large fires occurring within them. The impacts of fire are reflected in an updated habitat baseline and analyzed herein. The impacts from the fires have contributed to dispersal-habitat function challenges in the southern Oregon forest-landscape. However, the redundancy of the NWPF reserve system along with BLM increasing the acres of protected reserves under their recently revised RMP (which portions overlap critical habitat) is anticipated to continue to facilitate dispersal and connectivity function of critical habitat. Under the proposed action, only a minor amount of NRF removal (from 2 to 10 acres for any subunit) are proposed in the LSR system in the action areas. This amount of removal is not expected to alter the recovery functions of the LSR in the action area, nor the intended connectivity function of critical habitat. Whereas the greatest proportion of NRF removal within critical habitat within the action is proposed in the HLB, as expected under the RMP.

The proposed removal and downgrade of NRF and removal of dispersal-only habitat within critical habitat subunits KLE-3, KLE-5 and KLE-6 would not alter the intended subunit function of providing demographic support for spotted owls. This is because while adverse effects are anticipated from habitat removal and downgrade, incidental take of spotted owls is being avoided

under the proposed action. As a result, the demographic support function in these subunits is not anticipated to be meaningfully impacted (Assessment, p. 48).

**Beneficial Effects to Critical Habitat**

The following beneficial effects may be realized as a result of implementation of the proposed action:

- Thinning in simple stands of F (maintain and downgrade) and dispersal-only habitat would accelerate tree growth and promote the development of structurally complex forest conditions. See the Table 16 for site specific post-harvest desired conditions.
- Very dense stands would be opened by thinning, thereby improving the ability for spotted owls to disperse within these stands by providing more "flying space."
- Treated stands are likely to be more ecologically sustainable because residual stands would be less susceptible to suppression mortality, as well as mortality from insects and disease.
- Treated stands may provide additional protection to adjacent untreated NRF stands from wildfire by making more fire resilient stands through stand density and ladder fuel reduction.
- Single tree selection would reduce stand density to increase tree growth, quality, and vigor of the remaining trees; create diversified stand structure (height, age, and diameter classes), develop spatial heterogeneity within stands; increase resilience of forest stands to wildfire, drought, insects, by reducing stand density and ladder fuels; and increase growing space and decrease competition for large and/or legacy pine, oak, and cedar.

**Summary for Critical Habitat**

The Bear Grub and Round Oak Action Areas consist of effects to 6,050 acres of spotted owl habitat. Of which, 3,100 acres impacted will be due to the removal and downgrade of NR/F habitats. Overall, the proposed action would lead to a 0.01 (KLE-3), 5 (KLE-5) and 0.6 (KLE-6) percent reduction of the NRF (PBFs 2 and 3) habitat baseline (Table 18).

Vegetation and fuels management in dry and mixed-dry forests, such as in the action area, may be appropriate both within and outside designated critical habitat where the goal of such treatment is to conserve natural ecological processes or restore them (including fire) where they have been modified or suppressed (Allen *et al.* 2002, pp. 1429–1430; Spies *et al.* 2006, pp. 358–361; Fiedler *et al.* 2007, entire; Prather *et al.* 2008, entire; Lindenmayer *et al.* 2009, p. 274; Tidwell 2011, entire; Stephens *et al.* 2009, pp. 316–318; Stephens *et al.* 2012, pp. 557–558; Franklin *et al.* 2008, p. 46; Miller *et al.* 2009, pp. 28–30; Fule *et al.* 2012, pp. 75–76) (USDI FWS 2012b). These types of management activities are encouraged in the RMP through treatments in the HLB UTA. While some of the actions are considered as "habitat removal", UTA prescriptions provide for the retention of forest structure based on current stand condition(s) and the retention will provide for more rapid development of older forest characteristics relative to a regeneration harvest. The UTA prescriptions include leaving some

larger diameter trees and thinning across all diameter classes which eventually promotes broader forest structure. Uneven-aged management in these stands are expected to promote restoration of natural disturbance regimes, compared to regeneration type treatments. The Service's Opinion on the RMP concluded that these losses would be offset because during this same time span because critical habitat in the LSR LUAs are expected to develop spotted owl habitat through ingrowth (see LSR section below) and management actions such as thinnings designed to speed the development of critical habitat PBFs (USDI FWS 2016, pp. 690 and 691).

Despite potential adverse effects associated with habitat removal, the type, location, and proportional impacts will not affect the designated function of critical habitat at the action area or the subunit scale (between 0.01 and 5 percent). These actions will not compromise the capability the affected subunits to fulfill its intended conservation function, nor does this represent an appreciable reduction in the conservation value of the entire designated critical habitat. In some cases, these reductions occur in areas of low likelihood of use and are expected to result in a landscape that will be more resilient to future disturbances.

The proposed action is consistent with the Service's Opinion on the BLM's RMP. Analyzed in context with the Plan's provisions for ingrowth, the proposed action is not expected to alter any critical habitat subunit to a point that would appreciably diminish the value of critical habitat sub-units for the conservation of spotted owls, as:

- adverse impacts will occur on only a very small portion of these sub-units;
- the ability of the sub-units to support dispersing spotted owls are expected to be retained post-treatment supporting the life history needs of dispersing spotted owls;
- demographic support is not expected to be compromised because incidental take of spotted owls are not anticipated.

Overall, no adverse impacts are expected at the scale of spotted owl critical habitat units, as only minimal adverse effects are expected at the sub-unit scale. No adverse impacts are expected at the scale of spotted owl network, as only minimal adverse effects are expected at the unit scale. For these reasons, adverse modification to critical habitat is not expected.

While many of the spotted owl sites would be adversely affected, these sites are not currently occupied. Surveys are ongoing and units would be dropped or modified if resident singles or territorial pairs are located. Therefore, even though adverse effects are likely at these sites, PDC and conservation measures are in place that would avoid affecting owls and the demographic support of these sub-units.

**Contribution to Recovery**

Spotted owl critical habitat was designated to provide for adequate amounts of habitat to allow for recovery of the species across the range. Although most of the designated network occurs on Federal lands managed by the USFS, 12 percent of the overall network is managed by BLM under the RMP. Of this total on BLM lands, 15 percent (or 1.8 percent of the overall spotted owl critical habitat designation) is within the HLB and is potentially adversely affected by the RMP proposed action.

Removal of habitat has the potential to preclude spotted owl dispersal through the harvest or modified stands in the HLB. As noted in the spotted owl critical habitat revision (USDI FWS 2012a), the ability of spotted owls to disperse is a biological need best assessed at a landscape scale larger than a forest stand. In the Service's Opinion (p. 584) on the RMP, the Service concluded that the spatial configuration of reserves, the management of those reserves to retain, promote and develop spotted owl habitat, the management of the HLB and the scheduling of the management of the HLB are expected to provide for spotted owl dispersal between physiographic provinces/modeling regions and between and among large blocks of spotted owl habitat designed to support clusters of reproducing spotted owls. Therefore, the Service does not expect timber harvest, such as proposed herein, during the interim (take avoidance) period to influence the distribution of spotted owls at the local, action area or range-wide scales.

This critical habitat network is expected to provide for nesting/roosting, foraging and dispersal of spotted owls across the BLM lands. This is because the BLM has located their LSRs where modeling demonstrates that large blocks of critical habitat PBF 2 (nesting/roosting habitat) can form in a well-distributed manner across the BLM lands. Because the critical habitat network was designed in the same manner, there is substantial overlap of critical habitat and the reserved LUAs. We expect a substantial improvement in the condition of spotted owl critical habitat PBFs in these reserves. By distributing the reserved LUAs to incorporate blocks of high-quality critical habitat across BLM lands, the role of critical habitat in providing spotted owl immigration and emigration will be facilitated. Demographic and genetic interchange are both vital to the conservation of spotted owls, and PBF 2 represents the highest quality dispersal habitat. Spotted owls are expected to be able to utilize spotted owl critical habitat that is PBFs 2, 3 and 4 within these reserves for movement within and between reserves. In addition, portions of the HLB that are critical habitat may also provide areas of support for spotted owl movement. Although PBFs 2, 3 and 4 will be lost in critical habitat across the HLB where timber management occurs, these losses will occur over the next 50 years which will retain some of those habitat elements in declining amounts over the next five decades. The HLB is not where recovery of the spotted owl will be focused. Future development of spotted owl habitat and management of barred owls in the LSR LUA is expected to provide for territories that will support future spotted owl populations (USDI FWS 2016 p. 583). Under the RMP, individual projects, such as proposed herein, while having adverse effects, are expected to have an overall net positive conservation outcome at the landscape scale of the plan and to improve habitat conditions for the spotted owl in the LSRs (USDI FWS 2016 pp 637-638).

## CONSIDERATION OF THE SPOTTED OWL RECOVERY PLAN

The *Revised Recovery Plan for the Spotted Owl* (USDI FWS 2011) identifies discrete recovery units throughout the entire range of the spotted owl. These recovery units are based on physiographic provinces defined by unique biological and physical factors that provide essential survival and recovery functions for the spotted owl. The Plan identifies the primary range-wide threats to the spotted owl as competition with the barred owl and habitat loss or degradation, primarily from stand-replacing wildfire and other disturbances. The Plan describes a Recovery Strategy and discretionary Recovery Actions that includes habitat conservation and active forest management as necessary steps to address these threats; including: conserving more occupied

habitat and unoccupied high-value habitat; and encouraging and initiating active management actions that restore, enhance and promote development of high value habitat, consistent with broader ecological restoration goals (USDI FWS 2011, III-4-5). Specific text in the Plan addresses the disparate issues which face the spotted owl across its range.

In the disturbance-prone drier forests of the Oregon Klamath and the southern Oregon west Cascades Physiographic Provinces, where the District's FY20 Batch of Projects are located, the Plan recommends, through discretionary actions, that active management be conducted "in a way that reconciles overlapping goals of spotted owl conservation, responding to climate change and restoring dry forest ecological structure, composition and processes, including wildfire and other disturbances (USDI FWS 2011, III 20-21).

The Klamath Province, in particular, is threatened by ongoing habitat loss as a result of wildfire and effects of fire exclusion on vegetation change (USDI FWS 2011, I-8). The dry forests of the southern Oregon Cascades are more similar to forests in the Klamath Province than farther north in the Cascades and susceptible to wildfire (see Davis et al. 2016, p. 39 and Figure 13). Potential management in older forests, either for climate-related management or spotted owl recovery, must explicitly weigh the relative trade-offs of silvicultural activities in these systems (USDI FWS 2011 III-18).

As a general rule, forest management activities that are likely to diminish a home range's capability to support spotted owl occupancy and reproduction in the long-term should be discouraged. However, the Service recognizes that land managers have a variety of forest management obligations. Including that it may be necessary to maintain or improve ecological conditions where the intent is to provide long-term benefits to forest resiliency and restore natural forest dynamic processes, when implemented in a landscape context and carefully applied prescriptions (USDI FWS 2011, III-45). Such actions may include silvicultural treatments that promote ecological restoration and are expected to reduce future losses of spotted owl habitat and improve overall forest ecosystem resilience to climate change, which should result in more habitat retained on the landscape for longer periods of time (USDI FWS 2011, II-11). Land managers should not be so conservative that, to avoid risk, they forego actions that are necessary to conserve the forest ecosystems that are necessary to the long-term conservation of the spotted owl. But they should also not be so aggressive that they subject spotted owls and their habitat to treatments where the long-term benefits do not clearly outweigh the short-term risks. Finding an appropriate balance to this dichotomy will be an ongoing challenge for all engaged in spotted owl conservation and Federal actions will be subject to section 7 consultation allowing for site specific analysis of effects on spotted owls (USDI FWS 2011, II-11-12).

Increasingly, objectives for forests with moderate- or mixed-severity fire regimes, such as in southwestern Oregon, are to restore successfully diverse landscapes that are resistant and resilient to current and future stressors (Hessberg et al. 2016). Best available information indicates that large portions of the forested landscape in the southern Oregon have missed frequent, low-intensity fires, and current conditions of stands are severely departed from historic conditions (Hessberg et al. 2016 and Haugo et al. 2015). This leads to the prospect of more high severity and extent of large-scale fires, as suggested by Davis et al. (2016). There is scientific debate regarding past and future fire frequency in the dry forest systems and whether to actively

manage at risk stands (Hessberg et al. 2016 and Odion et al. 2014). The Recovery Plan and Critical Habitat rule acknowledged differences of opinion in the literature but concluded that active forest management is needed in dry-forests.

Recovery plans are not regulatory documents; rather, they provide guidance (discretionary) to bring about recovery and establish criteria to be used in evaluating when recovery has been achieved. The BLM continues to work with the Service to incorporate Recovery Goals and Actions consistent with BLM laws and regulations and the Service's Northern Spotted Owl Recovery Plan (USDI FWS 2011). The BLM is a participant in the inter-organizational spotted owl working group (Recovery Action 1) and will continue demographic monitoring to address Recovery Actions 2 and 3. Regionally, the BLM is assisting in spotted owl conservation through implementation of Recovery Action 29, which is the experimental removal of barred owls. During this experiment, the BLM will not authorize timber harvest activities that would result in incidental take of spotted owls.

Besides the broader recovery actions mentioned above, three recovery actions are relevant to the FY20 Batch of Projects: 6, 10 and 32 were applied/incorporated at the RMP and therefore District level. Each of these discretionary recovery actions are discussed below. Further, the Plan recommends continued application of the NWFP reserve network (USDI FWS 2011, p. III-41) on Forest Service administered lands along with the BLM's 2016 RMP Late-Successional Reserves which helps the Service evaluate projects, such as the FY20 Batch of Projects, in terms of their ability to contribute to the overall recovery of the spotted owl.

**Recovery Action 6 –** *"..modify younger stands to accelerate the development of structural complexity…"*

Approximately 338 acres of thinning treatments (262 acres in Bear Grub and 76 acres in Round Oak) are prescribed units proposed in dispersal-only habitat and capable habitat that have the potential to develop into nesting habitat based on their plant association series and site potential (Assessment, p.51). These treatments would accelerate the development of structural complexity and biological diversity.

**Recovery Action 10 –** "*Conserve spotted owl sites and high value spotted owl habitat to provide additional demographic support to the spotted owl population*."

The FY20 Batch of Projects incorporated Recovery Action 10 principles to the extent it was compatible with the primary purpose and need of the forest management projects. To inform BLM decisions on avoiding and minimizing impacts to spotted owls, the District prioritized spotted owl sites based on occupancy status. If occupied, the District would conduct modify treatments to maintain habitat function, and/or would not remove habitat below best available information for habitat fitness. However, in order to meet other management directions, treatments are proposed in known home ranges (Assessment and USDI BLM 2016a, Appendix A entire).

Further, District staff has/will work collaboratively to design treatments that will avoid incidental take of spotted owls due to habitat modifying actions, until implementation of a barred owl

management program is in place (USDI BLM 2016a, p. 30). Spotted owl sites and NRF habitat associated with harvest units will be surveyed to protocol (USDI FWS 2012a) prior to harvest and if spotted owls are located, the BLM will drop or modify the prescriptions to reduce potential adverse effects to spotted owls and avoid incidental take of spotted owls. BLM's take avoidance strategy is their primary contribution to Recovery Action 10 implementation.

**Recovery Action 32 –** *"Because spotted owl recovery requires well distributed, older and more structurally complex multi-layered conifer forests on Federal and non-federal lands across its range, land managers should work with the Service as described below to maintain and restore such habitat while allowing for other threats, such as fire and insects, to be addressed by restoration management actions. These high- quality spotted owl habitat stands are characterized as having large diameter trees, high amounts of canopy cover, and decadence components such as broken-topped live trees, mistletoe, cavities, large snags, and fallen trees*."

The intent of Recovery Action 32 is to maintain the older and more structurally complex multi-layered conifer forests on federal lands in order to not further exacerbate the competitive interactions between spotted owls and barred owls (USDI FWS 2011 III-67; USDA and USDI 2010). The land use allocations, management direction, and the guidance in the RMP provides contributions toward Recovery Action 32 (USDI BLM 2016a) (Assessment, p. 52).

Management Direction in the SWO RMP/ROD (USDI BLM 2016a, p. 71) directs "protection" of structurally complex forests specifically identified at the stand level which was mapped based on data base inquiries during the RMP development process. This mapping process resulted in having 7,571 acres of mapped LSR (including stand level mapped LSR) in the Bear Grub and Round Oak Action Areas. Approximately, 447 acres of these mapped LSR (RA32) seven percent) are proposed for treatment (443 acres in the Bear Grub Project and 4 acres in the Round Oak Project). However, these acres do not have the characteristics of a structurally complex forest, so there would be no effect to Recovery Action 32 type habitat from this treatment. These were field verified by the wildlife staff. Field level identification of structurally complex forest at the District level was informed by the interagency SW Oregon process for determining structurally complex forest (USDA USDI 2010).

None of the LSR LUA that has been field verified to be structurally complex would be removed or downgraded in these action areas. The LSR (District Identified structurally complex habitat (Recovery Action 32) Acres) LUAs constitute the BLM's contribution to Recovery Action 32 in the Revised Recovery Plan for the Northern Spotted Owl (USDI FWS 2011) (USDI BLM 2016a).

Besides the RMP/ROD directed complex forest identification for LSRs, District staff conducted field work to identify structurally complex forest within the Bear Grub and Round Oak treatment units. This field-based survey resulted in the identification of 281 acres of Recovery Action 32 habitat in the HLB LUA (Assessment Table 20). Of the 281 acres, the District proposes treatment, collectively of 256 acres: 68 acres in Bear Grub and 188 acres in Round Oak action areas. The proposed treatment is consistent with direction in the SWO RMP/ROD not to forego timber harvest of stands in the HLB (USDI BLM 2016a, p. 127).

The Service's Opinion of the RMP anticipated that the majority, but not all, of the structurally complex forest would be mapped and designated as LSR LUA (USDI FWS 2016, pp. 225, 236, 522 and USDI BLM 2016a). Overall though, the 2016 RMP provides extensive protection of structurally complex habitat through the LSR protections. For example, within the two action areas, there is approximately 7,571 acres of identified in the 2016 RMP GIS layers as structurally complex, multilayered stands potentially meeting Recovery Action 32. Harvest activities are prohibited in these stands with the exception of certain situations (USDI BLM 2016a, p.71 footnote). These acres comprise 22 percent of the total reserve acres in the combined action areas (33,959 acres). There are nearly 175,000 acres more habitat in reserves under the 2016 RMP compared to previous BLM RMPs.

<table>
<tr><th colspan="5">Table 19. Recovery Action 32 Summary for the Bear Grub and Round Oak Projects, Medford District BLM FY20 Batch of Projects.</th></tr>
<tr><th rowspan="2">Project</th><th colspan="2">District Identified structurally complex habitat (Recovery Action 32) Acres</th><th colspan="2">Treated Structurally Complex Habitat Acres</th></tr>
<tr><th>District Staff Field Identified in Project Area in HLB</th><th>2016 SWO RMP/ROD Mapped LSR/RA 32 Habitat in the Action Area</th><th>HLB</th><th>2016 SWO RMP/ROD Mapped LSR/RA 32</th></tr>
<tr><td rowspan="2">Bear Grub</td><td rowspan="2">91<br>11 patches (0.5 to 32 acres)</td><td rowspan="2">5,112</td><td>68</td><td>443</td></tr>
<tr><td>68 acres removed</td><td>29 acres F removal (in low RHS and 2 in roads/landings)<br>56 acres F downgrade<br>86 F maintain<br>29 acres dispersal only removed (3 roads/landings)<br>83 acres dispersal-only maintain<br>161 acres non-habitat/capable</td></tr>
<tr><td rowspan="2">Round Oak</td><td rowspan="2">190<br>34 patches (0.1 to 30 acres)</td><td rowspan="2">2,459</td><td>188</td><td>4</td></tr>
<tr><td>183 acres removed<br>5 maintained</td><td>2 acres NR removal (roads/landings)<br>1 acre dispersal-only removal<br>1 acre capable</td></tr>
<tr><td>Total</td><td>281</td><td>7,571</td><td>256</td><td>447</td></tr>
</table>

## CUMULATIVE EFFECTS

Cumulative effects are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they will require separate consultation pursuant to section 7 of the Act.

Updates to habitat from post-harvest monitoring of recent BLM timber sales within these action areas have been included in this Opinion.

The Action Areas have a checkerboard pattern of ownership of private land interspersed with BLM. Management practices occurring on private lands range from residential home site development to intensive industrial timber management. The majority of state and private forests in Washington, Oregon, and Northern California are managed for timber production. Non-federal lands are not expected to provide demographic support for spotted owls across and between physiographic provinces (Thomas, et al. 1990; USDA and USDI 1994a). Historically, non-federal landowners practiced even-aged management (clear-cutting) of timber over extensive acreages. Private industrial forestlands are managed for timber production and will typically be harvested between 40 and 60 years of age, in accordance with State Forest Practices Act Standards.

The Medford BLM assumes past management practices on private lands will continue. The BLM anticipates some loss of owl habitat on private lands, but cannot predict the rate of loss, types of spotted owl habitat affected, or the specific location of harvest. BLM does not track private land harvest activity. Harvest activities, including salvage logging on state and private lands can be expected to impact spotted owls located within adjacent federal lands by removing and fragmenting habitat and through disturbance activities adjacent to occupied sites during sensitive periods. The Oregon Forest Practices Act Rules (OAR 629-665-0210) protects spotted owl nest sites (70-acre core areas) for at least three years after the last year of occupation.

Reciprocal ROW permit holders may fell hazard trees and adjacent trees on BLM lands. Landowners or their agents are required to obtain Road Use Permits to build roads across BLM managed land for commercial purposes or to haul commercial products on BLM maintained road systems. Reciprocal ROWs with private parties already cover many existing road activities in the Action Area. According to BLM Information Bulletin (IB) # OR-2000-174, this is a non-discretionary action, including the disposal of the logs. If these areas occur in LSR or Riparian Reserves, the BLM cannot ask the permittees to leave these trees as coarse woody debris.

The Service assumes that non-federal land management actions in the action areas would continue at current levels. Non-federal land conditions are expected to continue to degrade in the action areas over time, but it is the Federal lands in the action areas that are anticipated to provide for the long-term conservation of the spotted owl. Therefore, cumulative impacts do not change the significance of our determinations/finding made to the species under the effects of the proposed action section.

## CONCLUSION

After reviewing the current status of the spotted owl and its critical habitat, the environmental baseline for the action area, the effects of the proposed action, including all measures proposed to avoid and minimize adverse effects, and the cumulative effects, it is the Service's Biological Opinion that the action, as proposed, is not likely to jeopardize the continued existence of the spotted owl, and is not likely to destroy or adversely modify spotted owl critical habitat.

The Service reached these conclusions for the following reasons:

The majority of NRF habitat each action area, 96 and 83 percent for Bear Grub and Round Oak remains un-treated under the proposed action (Table 5, Table 6, and Table 12).

Approximately six percent of the Bear Grub and less than six percent of the Round Oak action areas are proposed for treatments. About 25 percent (1,018 acres) of the overall NRF treatment acres are outside of known spotted owl home ranges (Assessment Table 17). There are also 16 spotted owl site centers outside of the Action Area with a portion of the home range overlapping the Action Area and no treatments are proposed within these home ranges.

The adverse impacts of the proposed action are not expected to preclude the capability of spotted owls to disperse at a landscape scale because sufficient levels of dispersal quality- habitats are expected to be available for habitat connectivity as per individual watershed and collectively for the action areas.

Approximately 385 acres of dispersal-only habitat and approximately 312 acres of capable habitat are proposed for treatment (Modify) with the intended purpose of speeding the development trajectory toward NRF or dispersal-only only habitat. Depending current stand condition, development of spotted owl habitat could occur in the next 20-30 years.

Although there are 43 known spotted owl home ranges (including 3 home ranges with original and alternate site locations) that could be impacted, the RMP management direction calls for the avoidance of incidental take of spotted owls. Therefore, the impacts should not resonate to the provincial or range-wide scales.

Physical impacts to habitat and disturbances to individuals will be reduced or avoided per measures described in the PDCs. To avoid and minimize the disturbance, and/or physical injury distance to spotted owls, appropriate timing restrictions for proposed activities will be implemented by the District.

Spotted owl protocol (USDI FWS 2012a) surveys are still ongoing at the time of this consultation. If spotted owls are located during remaining protocol surveys before the time of on the ground implementation, units would be dropped or modified to eliminate potential adverse effects that could lead to an incidental take determination.

Over the last two decades, the rates of habitat loss from high severity fires have disproportionately affected Oregon and California Klamath Physiographic Provinces (particularly reserves) and to some extent the Oregon West Cascades province. Most of the overall losses (73 percent) occurred within the federally reserved land use allocations, or a loss of about 7.5 percent of the habitat reserved by the NWFP. The majority of these losses occurred in the California and Klamath Physiographic Provinces, largely resulting from the effects of high severity fires (Davis et al., 2011, p. iii; Davis et al. 2016, pages 23, 35-38). However, forest succession is resulting in habitat recruitment that has compensated somewhat for some of these losses from disturbances; therefore, the net decrease of habitat is less than the gross decrease as represented by the values presented above.

While NRF will be removed as a result of Bear Grub and Round projects, harvest activities in the HLB (MITA, LITA and UTA) are primarily for ASQ, secondarily are intended to create more fire resilient stands and may reduce the overall fire risk to remaining adjacent spotted owl habitat on the landscape. Harvest in the LSR is consistent with the RMP, toward developing spotted owl habitat.

The conservation needs of the spotted owl will continue to be met at the provincial and range-wide scale because the proposed action is consistent with the management direction and strategy of the BLM's RMP. For example, the RMP provides for the function of large blocks of habitat for reproducing spotted owls and the ability of the landscape to support spotted owl movement between those blocks. It is anticipated that the LSR related treatments will provide long-term habitat benefits such as tree diameter growth increases, multi-layered structure and species diversity development. However, immediate short-term impacts are anticipated due to the removal of key habitat features such as layers, perches for foraging, and some concealment cover. The Service's Opinion on the BLM's RMP concluded that these losses would be offset because during this same time span because critical habitat in the LSR LUAs are expected to develop spotted owl habitat through ingrowth and management actions such as thinnings designed to speed the development habitat.

In addition, the proposed action incorporates discretionary recommendations set forth in the Northern Spotted Owl Recovery Plan and as incorporated at the RMP level. This includes meeting the intent of Recovery Actions 6, 10, 29 and 32, along with implementing dry forest restoration treatments at the landscape scale. These type of treatments are discussed and encouraged in the Recovery Plan (USDI FWS 2011, pp III-32-39). While the proposed action is modifying (removing) high quality habitat as defined in the spotted owl recovery plan, the high quality habitat is primarily within the HLB and removing structurally complex habitat in the harvest land-base is anticipated under the Service's Opinion on the RMP. On a broad scale, the BLM is currently protecting more late-successional habitat through LSR protections than in previous RMPs which is likely to help reduce interference competition from barred owls.

With implementation of the proposed action, the vast majority of spotted owl NRF habitat in the action areas will be retained in a functional condition on the landscape. Although the loss or downgrade of existing NRF habitat is certainly an adverse effect to the spotted owl, the proposed action was specifically designed to disperse habitat impacts on the landscape in a manner that avoids take of spotted owls, enhances the resiliency of remaining stands in the action area to wildfire, and retains the capability of NRF habitat in the action area to support the life history requirements of the spotted owl. Wildfire has become a more significant threat to spotted owls and their habitat in this portion of its range due to higher than natural fuel-loading following decades of fire suppression and the warming and drying effects of climate change. Land management actions that enhance forest stand resiliency to wildfire, retain functional NRF habitat, and avoid take should benefit the conservation of the spotted owl. Therefore, population impacts are not expected to resonate at the range-wide level. As a result, the proposed action is not expected to jeopardize spotted owls at the range-wide scale where the jeopardy determination is made.

Overall, the proposed action would lead to a 0 (KLE-3), 5 (KLE-5) and 0.5 (KLE-6) percent reduction of the NRF (PBFs 2 and 3) habitat baseline (Table 18) within these critical habitat sub-units. The intended function of the subunits are for landscape connectivity and demographic support and are not expected to appreciably diminish as a result of the proposed action.

The District developed the Bear Grub and Round Oak projects consistent with the dry forest recommendations in the critical habitat rule so as to promote and conserve biodiversity, and restore more natural vegetation and disturbance regimes and heterogeneity conducive to the long-term conservation of the spotted owl (USDI FWS 2012b, pp. 71908-71911).

Despite potential adverse effects associated with habitat removal, the type, location, and proportional impacts will not affect the designated function of critical habitat at the action area or the subunit scale (between 0 and 5 percent). These actions will not compromise the capability the affected subunits to fulfill its intended conservation function, nor does this represent an appreciable reduction in the conservation value of the entire designated critical habitat. In some cases, these reductions occur in areas of low likelihood of use and are expected to result in a landscape that will be more resilient to future disturbances.

The Service, in August 2016, issued a non-jeopardy and non-adverse modification biological opinion (Opinion) (USDI FWS 2016) on the Bureau of Land Management's Resource Management Plan (USDI BLM 2016a) as related to the northern spotted owl and spotted owl critical habitat. Under the Opinion, the conservation needs (USDI FWS 2016, pp. 486-490) of the spotted owl were analyzed in relation to the Plan level RMP and the Service found the RMP to be consistent with the recovery needs of the spotted owl by providing for a well distributed network of large block reserves with adequate opportunities for dispersal and by supporting a barred owl management program if, after compliance with NEPA, MBTA and other applicable requirements, the Service decides such a program would be effective and feasible. The RMP also precludes incidental take of spotted owls from timber harvest until such a program is implemented or consultation is reinitiated. Finally, the Opinion concluded that the RMP is consistent with the functioning of the critical habitat network to serve its intended conservation role.

The proposed action is consistent with the Service's Opinion on the BLM's RMP. Analyzed in context with the Plan's provisions for ingrowth, the proposed action is not expected to alter any critical habitat subunit intended functions of connectivity and demographic support to a point that would appreciably diminish the value of critical habitat sub-units for the conservation of spotted owls, as:

- adverse impacts will occur on only a very small portion of these sub-units;
- the ability of the sub-units to support dispersing spotted owls are expected to be retained post-treatment supporting the life history needs of dispersing spotted owls;
- demographic support is not expected to be compromised because incidental take of spotted owls are not anticipated.

The proposed action is expected to improve the affected areas' resilience to climate changes, as the project is designed to reduce the action areas risk of uncharacteristic wildfire. Therefore, potential climate change interactions (i.e., changes in temperature and precipitation) do not

exacerbate the significance of our determinations/findings made to the species under the effects of the proposed action section.

In the Service's Opinion on the RMP, it was determined that spotted owl populations will continue to decline precipitously and be locally extirpated across the range due to barred owl competition regardless of how much habitat is conserved unless the barred owl threat is addressed. Modeling conducted to support the BLMs PRMP/FEIS and section 7 consultation supports the Service's opinion. In recognition of this the BLM and the Service developed a two part strategy to support the survival and recovery of northern spotted owls: the designation of the reserve network designed to protect and support development of existing and future spotted owl habitat sufficient for recovery of viable populations; and implementation of a barred owl management program meeting defined parameters to support spotted owl survival. Recognizing that a barred owl management plan would take time to develop and implement, the strategy also included avoidance of incidental take from timber harvest to minimize effects on survival. No incidental take from timber harvest activities will be authorized, until such time as a barred owl management program is implemented. It is the Service's opinion that the take prohibition combined with habitat protection and development in the reserve network adequately support northern spotted owl survival and recovery. If a barred owl strategy meeting the parameters described in the RMP Opinion is not implemented prior to 2024, BLM is supposed to re-initate consultation of the RMP and would be under the prohibitions of section 7(d) of the act.

As analyzed herein, while adverse effects to the spotted owl and spotted owl critical habitat are anticipated, the Service concludes that the District's implementation of the FY20 Batch of Projects are not likely to jeopardize the continued existence of the spotted owl or to destroy or adversely modify critical habitat and as such, are consistent with the Biological Opinion on the RMP.

## INCIDENTAL TAKE STATEMENT

From the analysis presented above, the Service determined that spotted owls are likely be adversely affected by the proposed action, but the proposed action is not likely to jeopardize the continued existence of the spotted owl, or result in the destruction or adverse modification of critical habitat. Spotted owls present in the project area could be exposed to stressors caused by the proposed action, but as part of the proposed action, the BLM will implement project design criteria such as timing restrictions to avoid or minimize disturbance of spotted owls; in addition, BLM will survey known spotted owl sites in areas proposed for treatment, and will drop the area from treatment, or modify the treatment prescription, to avoid take if spotted owls are detected. As such, the Service does not anticipate the Bear Grub and Round Oak proposed actions will incidentally take any spotted owls because take as defined in the Act is not reasonably certain to occur.

### Reasonable and Prudent Measures

No reasonable and prudent measures are set forth below because no take of the spotted owl is anticipated. However, the District has agreed under the proposed action to monitor impacts to spotted owls (Appendix C) during the course of the proposed action to ensure that the anticipated amount or extent of take (zero) is not exceeded.

### Terms and Conditions

No Terms and Conditions are provided in this Opinion because no incidental taking is anticipated.

If a dead, injured, or sick endangered or threatened species specimen is located, initial notification must be made to the nearest Service Law Enforcement Office, located at 9025 SW Hillman Court, Suite 3134, Wilsonville, OR 97070; phone: 503-682-6131 along with the local U.S. Fish and Wildlife Office in Roseburg, OR. Care should be taken in handling sick or injured specimens to ensure effective treatment or the handling of dead specimens to preserve biological material in the best possible state for later analysis of cause of death. In conjunction with the care of sick or injured endangered and threatened species or preservation of biological materials from a dead animal, the finder has the responsibility to carry out instructions provided by Law Enforcement to ensure that evidence intrinsic to the specimen is not unnecessarily disturbed.

If the exempted level of incidental take (zero) is exceeded or is likely to be exceeded based on the monitoring conducted by the District as part of the proposed action, reinitiation of formal consultation is required.

## CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

Implement PDCs as recommended.

## MONITORING

According to the District, timber sales are administered by an Authorized Officer and Contract Administrator. All other contracts are administered at the local level by Contracting Officer Representatives (CORs) and Project Inspectors (PI) throughout implementation until the project work is completed, or implemented by District staff. Timber sales also have a contract clause (E-3) that authorizes stop work when threatened or endangered species are found within the timber sale or to comply with court orders. When (and if) a spotted owl or other listed species is found in the project area, the District is authorized to stop the work until the issue is evaluated further. If a spotted owl or other listed species is found, biologists will review PDFs and PDC

and the appropriate consultation document to confirm the Endangered Species Act analysis remains valid. The District will also implement monitoring under the District's implementation monitoring strategy (USDI BLM Medford District 2015).

If the spotted owl (or other listed species) was not analyzed in the Assessment, if the project area changes from what was originally analyzed in the Assessment, if a site has moved, or other information is inconsistent with what is authorized, the District coordinates with project proponents, contractors, managers, local biologists and the Level 1 team to ensure the project impacts remain consistent with the Assessment and the responding consultation document (biological opinion or letter of concurrence). If not, the project will remain stopped until the District implements one or more of the following:

- Modify the proposed action to ensure that impacts remain as described in the consultation documents;
- Impose seasonal protection (if necessary);
- Re-initiate consultation.

**REINITIATION NOTICE**

The Assessment includes a finding that it may take several years to fully complete the Proposed Action. This consultation remains valid for the term of the action as discussed in these documents, provided the annual monitoring and reporting described in the Assessment is dutifully implemented. In accordance with the implementing regulations for section 7 at 50 CFR 402.16, re-initiation of consultation on the proposed action is required where discretionary Federal agency involvement or control over the actions has been maintained (or is authorized by law) and if: (1) the amount or extent of exempted incidental take is exceeded; (2) new information reveals effects of the agencies' action that may affect listed species or critical habitat in a manner or to an extent not considered in the consultation; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the consultation or (4) a new species is listed or critical habitat designated that may be affected by one or both of these actions. When consultation is reinitiated, the provisions of section 7 (d) of the ESA apply.

If you have any questions regarding this consultation, please contact Michael Asch at 541-957-3469.

cc: Robin Snider, Medford District BLM
Dave Clayton, Rogue River-Siskiyou National Forest

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## Personal Communication

R. Snider, Medford District BLM biologist, July 19, 2020 (Email correspondence from the BLM).

**Associated Federal Register Documents**

55 FR 26114: Determination of Threatened Status for the Northern Spotted Owl. Final Rule. Published in the Federal Register on January 26, 1990. 26114-26194.

57 FR 1796: Endangered and Threatened Wildlife and Plants; determination of critical habitat for the northern spotted owl. Final Rule. Published in the Federal Register on January 15, 1992. 1796-1838.

58 FR 14248: Final Rule To List the Mexican Spotted Owl as a Threatened Species. Final Rule. Published in the Federal Register on March 16, 1993. 14248-14271.

73 FR 29471: Proposed Revised Designation of Critical Habitat for the Northern Spotted Owl (*Strix occidentalis caurina*). Proposed rule. In addition, this document announced that the Final Recovery Plan for the Northern Spotted Owl is available. Published in the Federal Register on May 21, 2008. 29471-29477.

73 FR 47326: Revised Designation of Critical Habitat for the Northern Spotted Owl; Final Rule. Published in the Federal Register on Federal Register on August 13, 2008. 47326-47522.

76 FR 38575: Revised Recovery Plan for the Northern Spotted Owl (*Strix occidentalis caurina*). Notice of document availability: revised recovery plan. Published in the Federal Register on July 1, 2011. 38575-38576.

76 FR 63719: 12-Month Finding on a Petition To List a Distinct Population Segment of the Red Tree Vole as Endangered or Threatened. Proposed Rule. Published in the Federal Register on October 13, 2011. 63720-63762.

77 FR 71876: Designation of Revised Critical Habitat for the Northern Spotted Owl. Final Rule. Published in the Federal Register on December 4, 2012. 71876-72068.

78 FR 57171: Experimental Removal of Barred Owls To Benefit Threatened Northern Spotted Owls; Record of Decision for Final Environmental Impact Statement. Notice of availability September 17, 2013. 57171-57173.

80 FR 19259. 90-Day Findings on 10 Petitions. Notice of petition findings and initiation of status reviews. Published in the Federal Register on April 10, 2015. 19259-72068.

# APPENDIX A. STATUS OF THE SPECIES - NORTHERN SPOTTED OWL

## Northern Spotted Owl

### Legal Status

The northern spotted owl was listed as threatened on June 26, 1990 due to widespread loss and adverse modification of suitable habitat across the owl's entire range and the inadequacy of existing regulatory mechanisms to conserve the owl (USDI FWS 1990a, p. 26114). Listing priority numbers are assigned on a scale of 1C (highest) to 18 (lowest). The "C" reflects conflict with development, construction, or other economic activity (USDI FWS 1983, p. 43104). The northern spotted owl was originally listed with a recovery priority number of 3C, but that number was changed to 6C in 2004 during the 5-year review of the species (USDI FWS 2004, p. 55). This number reflects a high degree of threat, a low potential for recovery, and the owl's taxonomic status as a subspecies (USDI FWS 1983, p. 51895). The most recent five year status review was completed on September 29, 2011, and did not propose changes to the listing status or introduce any new threats (USDI FWS 2011a). In 2012, the U.S. Fish and Wildlife Service (Service) was petitioned to uplist the northern spotted owl from threatened to endangered status under the Endangered Species Act. In April 2015, the Service determined that petition presented substantial information indicating that the listing may be warranted due to a number of listing factors (USDI FWS 2015, pp.19259-19263). The species' status report is currently under review.

### Life History

*Taxonomy*

The northern spotted owl is one of three subspecies of spotted owls currently recognized by the American Ornithologists' Union. The taxonomic separation of these three subspecies is supported by genetic (Barrowclough and Gutiérrez 1990, pp.741-742; Barrowclough et al. 1999, p. 928; Haig et al. 2004, p. 1354), morphological (Gutiérrez et al. 1995, p. 2), and biogeographic information (Barrowclough and Gutiérrez 1990, p.741-742). The distribution of the Mexican subspecies (*S. o. lucida*) is separate from those of the northern and California (*S. o. occidentalis*) subspecies (Gutiérrez et al. 1995, p.2). Recent studies analyzing mitochondrial DNA sequences (Haig et al. 2004, p. 1354; Chi et al. 2004, p. 3; Barrowclough et al. 2005, p. 1117) and microsatellites (Henke et al., unpubl. data, p. 15) confirmed the validity of the current subspecies designations for northern and California spotted owls. The narrow hybrid zone between these two subspecies, which is located in the southern Cascades and northern Sierra Nevada, appears to be stable (Barrowclough et al. 2005, p. 1116).

Funk et al. (2008, pp. 1-11) tested the validity of the three current recognized subspecies of spotted owls and found them to be valid. During this genetics study, bi-directional hybridization and dispersal between northern spotted owls and California spotted owls centered in southern Oregon and northern California was discovered. In addition, a discovery of intro-regression of

Mexican spotted owls into the northernmost parts of the northern spotted owl populations in Washington was made, indicating long-distance dispersal of Mexican spotted owls into the northern spotted owl range (Funk et al. 2008, pp. 1-11). Some hybridization of northern spotted owls with barred owls has been recorded (Hamer et al. 1994, pp. 487-491; Dark et al. 1998, pp. 50-56; Kelly 2001, pp. 33, 38). *Physical Description*

The northern spotted owl is a medium-sized owl and is the largest of the three subspecies of spotted owls (Gutiérrez et al. 1995, p. 2). It is approximately 46 to 48 centimeters (18 inches to 19 inches) long and the sexes are dimorphic, with males averaging about 13 percent smaller than females. The mean mass of 971 males taken during 1,108 captures was 580.4 grams (1.28 pounds) (out of a range 430.0 to 690.0 grams) (0.95 pound to 1.52 pounds), and the mean mass of 874 females taken during 1,016 captures was 664.5 grams (1.46 pounds) (out of a range 490.0 to 885.0 grams) (1.1 pounds to 1.95 pounds) (Loschl, P. and E. Forsman pers. comm. 2006 cited in USDI FWS 2011b, p. A-1). The northern spotted owl is dark brown with a barred tail and white spots on its head and breast, and it has dark brown eyes surrounded by prominent facial disks. Four age classes can be distinguished on the basis of plumage characteristics (Forsman 1981; Moen et al. 1991, p. 493). The northern spotted owl superficially resembles the barred owl, a species with which it occasionally hybridizes (Kelly and Forsman 2004, p. 807). Hybrids exhibit physical and vocal characteristics of both species (Hamer et al. 1994, p. 488).

*Current and Historical Range*
The current range of the spotted owl extends from southwest British Columbia through the Cascade Mountains, coastal ranges, and intervening forested lands in Washington, Oregon, and California, as far south as Marin County (USDI FWS 1990a, p. 26115). The range of the spotted owl is partitioned into 12 physiographic provinces (see Figure A-1) based on recognized landscape subdivisions exhibiting different physical and environmental features (USDI FWS 2011b, p. III-1; Thomas et al. 1993). These provinces are distributed across the species' range as follows:

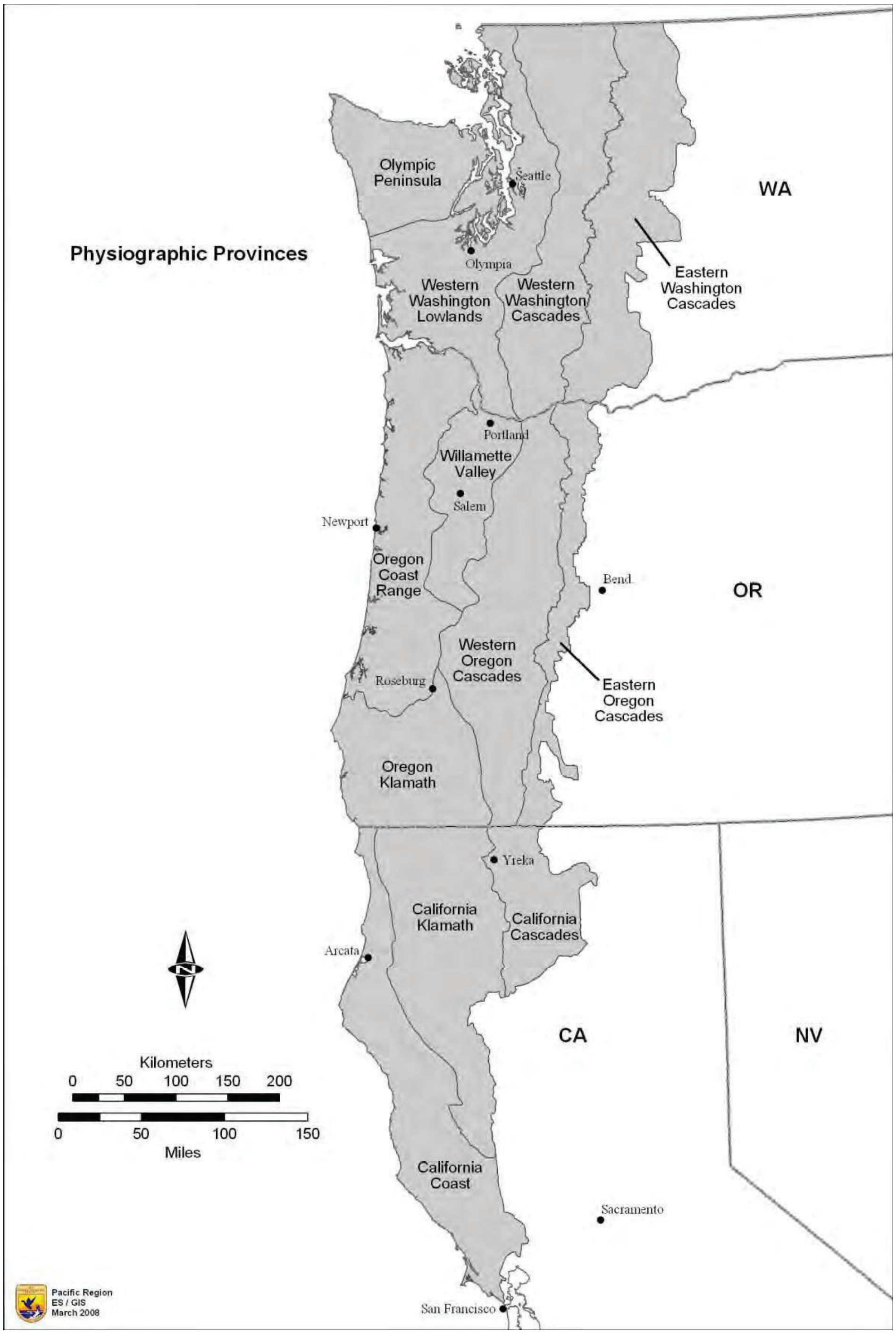
- Four provinces in Washington: Eastern Washington Cascades, Olympic Peninsula, Western Washington Cascades, Western Washington Lowlands
- Five provinces in Oregon: Oregon Coast Range, Willamette Valley, Western Oregon Cascades, Eastern Oregon Cascades, Oregon Klamath
- Three provinces in California: California Coast, California Klamath, California Cascades

The spotted owl is extirpated or uncommon in certain areas such as southwestern Washington and British Columbia. Timber harvest activities have eliminated, reduced or fragmented spotted owl habitat sufficiently to decrease overall population densities across its range, particularly within the coastal provinces where habitat reduction has been concentrated (USDI FWS 2011b, pp. B-1 to B-4; Thomas and Raphael 1993).

*Behavior*
Northern spotted owls are primarily nocturnal (Forsman et al. 1984, pp. 51-52) and spend virtually their entire lives beneath the forest canopy (Courtney et al. 2004, p. 2-5). They are adapted to maneuverability beneath the forest canopy rather than strong, sustained flight

(Gutiérrez et al. 1995, p. 9). They forage between dusk and dawn and sleep during the day with peak activity occurring during the two hours after sunset and the two hours prior to sunrise

**Figure A-1. Physiographic Provinces within the range of the northern spotted owl in the United States (from USDI FWS 2011b, A-3)**



(Gutiérrez et al. 1995, p. 5; Delaney et al. 1999, p. 44). They will sometimes take advantage of vulnerable prey near their roosts during the day (Layman 1991, pp. 138-140; Sovern et al. 1994, p. 202).

Northern spotted owls seek sheltered roosts to avoid inclement weather, summer heat, and predation (Forsman 1975, pp. 105-106; Barrows and Barrows 1978; Barrows 1981; Forsman et al. 1984, pp. 29-30). Northern spotted owls become stressed at temperatures above 28°C, but there is no evidence to indicate that they have been directly killed by temperature because of their ability to thermoregulate by seeking out shady roosts in the forest understory on hot days (Barrows and Barrows 1978; Forsman et al. 1984, pp. 29-30, 54; Weathers et al. 2001, pp. 678, 684). During warm weather, spotted owls seek roosts in shady recesses of understory trees and occasionally will even roost on the ground (Barrows and Barrows 1978, pp. 3, 7-8; Barrows 1981, pp. 302-306, 308; Forsman et al. 1984, pp. 29-30, 54; Gutiérrez et al. 1995, p. 7). Glenn et al. (2010, p. 2549) found that population growth was negatively associated with hot summer temperatures at their southernmost study area in the southern Oregon Cascades, indicating that warm temperatures may still have an effect on the species. Both adults and juveniles have been observed drinking water, primarily during the summer, which is thought to be associated with thermoregulation (Gutiérrez et al. 1995, p. 7).

Spotted owls are territorial; however, home ranges of adjacent pairs overlap (Forsman et al. 1984, p. 22; Solis and Gutiérrez 1990, p. 746) suggesting that the area defended is smaller than the area used for foraging. They will actively defend their nests and young from predators (Forsman 1975, p. 15; Gutiérrez et al. 1995, p. 11). Territorial defense is primarily effected by hooting, barking and whistle type calls. Some spotted owls are not territorial but either remain as residents within the territory of a pair or move among territories (Gutiérrez 1996, p. 4). These birds are referred to as “floaters.” Floaters have special significance in spotted owl populations because they may buffer the territorial population from decline (Franklin 1992, p. 822). Little is known about floaters other than that they exist and typically do not respond to calls as vigorously as territorial birds (Gutiérrez 1996, p. 4).

Spotted owls are monogamous and usually form long-term pair bonds. “Divorces” occur but are relatively uncommon. There are no known examples of polygyny in this owl, although associations of three or more birds have been reported (Gutiérrez et al. 1995, p. 10).

*Habitat Relationships*

Home Range and Core Areas

Spotted owls are territorial raptors that range widely in search of prey but are ‘anchored’ during the breeding season to a nest site (central-place forager). Evaluations of spotted owl habitat are usually conducted at two spatial scales; the home range and core areas. The home range is the “area traversed by the individual in its normal activities of food gathering, mating, and caring for young” (Burt 1943:351, cited in USDI FWS 2009). Within home ranges, areas receiving concentrated use, typically surrounding the nest site and favored foraging areas, are called core areas. Because the size and pattern of spotted owl’s space use are typically unknown, estimates of use areas are derived from radio-telemetry studies. Results from Bingham and Noon (1997) showed that spotted owls typically used 20-21 percent of their home range as core use area

habitat, which generally included 60-70 percent of the sites within their home range used during the breeding season. As central place foragers, nesting spotted owls are likely very sensitive to activities that occur within their core use areas and especially their nest patch (Swindle et al. 1997, Miller et al. 1989, and Meyer et al. 1998).

The habitat composition within cores and annual home ranges has been found to be directly correlated with demographic response such as occupancy, reproductive success, survival, and fitness. Meyer et al. (1998) examined landscape indices associated with spotted owl sites versus random plots on BLM lands throughout Oregon. Across provinces, landscape indices highly correlated with the probability of spotted owl occupancy included the percent older forest (30 percent) within the 500 acres (analogous to a core-use area) surrounding the site. Zabel et al. (2003, abstract, p. 1033) found the best-fitting model for owl occupancy predictions in northwest California was at the 200-ha (500 acre) scale. Their model found a pseudo-threshold relationship to nesting and roosting habitat (meaning once the quantity of the habitat metric reached some ‘‘threshold’’ level the probability of occupancy did not increase or decrease substantially with more habitat) and a quadratic relationship to foraging habitat. Bart (1995) found that core areas should contain 30-50 percent mature and old growth forest. Results from Thomas et al. (1990), Bart and Forsman (1992) Bart (1995) and Dugger et al (2005) suggest that when spotted owl home ranges have less than 40 to 60 percent nesting/roosting/foraging (NRF), they were more likely to have lower occupancy and fitness. Olson et al. (2005) found similar results on their Oregon Coast Ranges study area.

As further described in the 2009 FWS Guidelines (USDI FWS 2009, “Guidelines”), the probability of occupancy is increased when core areas contain a range of habitat conditions suitable for use by spotted owls, and the survival and fitness of spotted owls is positively correlated with larger patch sizes or proportion of older forests (Franklin et al. 2000, Dugger et al. 2005). The Guidelines express “the strongest type of information relevant to the evaluation of take relates to the fitness of spotted owls to characteristics of their habitat.” Depending on the availability of habitat, fitness may be compromised when additional habitat degradation or losses occur. The final evaluation of incidental take is both a quantitative and qualitative analysis of the actual amount and distribution of habitat available to the spotted owl when compared to the effects of the proposed action and site specific conditions.

Recently developed habitat-fitness and landscape models have demonstrated the importance of having sufficient amounts of NRF habitat within core use areas to adequately provide for spotted owl survival and reproduction along with access to prey. For example, Franklin et al. (2000) found that the proportion of good habitat was around 60 percent to lesser quality habitat for owl core use areas in northwest California. In a recently published study of spotted owls in the Oregon Klamath Province, survival was negatively correlated with forest fragmentation (Schilling et al. 2013).

Home-range sizes vary geographically, generally increasing from south to north, which is likely a response to differences in habitat quality (USDI FWS 1990a, p. 26117). Estimates of median size of their annual home range (the area traversed by an individual or pair during their normal activities (Thomas and Raphael 1993, pp. IX-15)) vary by province and range from 2,955 acres in the Oregon Cascades (Thomas et al. 1990, p. 194) to 14,211 acres on the Olympic Peninsula

(USDI FWS 1994, p. 3). Zabel et al. (1995, p. 436) showed that these provincial home ranges are larger where flying squirrels are the predominant prey and smaller where wood rats are the predominant prey. Home ranges of adjacent pairs overlap (Forsman et al. 1984, p. 22; Solis and Gutiérrez 1990, p. 746), suggesting that the defended area is smaller than the area used for foraging. Spotted owl core areas vary in size geographically and provide habitat elements that are important for the reproductive efficacy of the territory, such as the nest tree, roost sites and foraging areas (Bingham and Noon 1997, p. 134). Some studies have found that spotted owls use smaller home ranges during the breeding season and often dramatically increase their home range size during fall and winter (Forsman et al. 1984, pp. 21-22; Sisco 1990, p. iii). In Southern Oregon, one study found that home range and core areas remained essentially the same between seasons, concluding that perhaps this was due to the quality of available habitat (Shilling et al. 2013).

Although differences exist in natural stand characteristics that influence home range size, habitat loss and forest fragmentation effectively reduce habitat quality in the home range. A reduction in the amount of suitable habitat reduces spotted owl abundance and nesting success (Bart and Forsman 1992, pp. 98-99; Bart 1995, p. 944).

Habitat Use and Selection

Forsman et al. (1984, pp.15-16) reported that spotted owls have been observed in the following forest types: Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), grand fir (*Abies grandis*), white fir (*Abies concolor*), ponderosa pine (*Pinus ponderosa*), Shasta red fir (*Abies magnifica shastensis*), mixed evergreen, mixed conifer hardwood (Klamath montane), and redwood (*Sequoia sempervirens*). The upper elevation limit at which spotted owls occur corresponds to the transition to subalpine forest, which is characterized by relatively simple structure and severe winter weather (Forsman 1975, p. 27; Forsman et al. 1984, pp. 15-16).

Spotted owls generally rely on older forested habitats because such forests contain the structures and characteristics required for nesting, roosting, and foraging. Features that support nesting and roosting typically include a moderate to high canopy closure (60 to 80 percent); a multi-layered, multi-species canopy with large overstory trees (with diameter at breast height [dbh] of greater than 30 inches); a high incidence of large trees with various deformities (large cavities, broken tops, mistletoe infections, and other evidence of decadence); large snags; large accumulations of fallen trees and other woody debris on the ground; and sufficient open space below the canopy for spotted owls to fly (Thomas et al. 1990, p. 19). Weathers et al. 2001, (p. 686) found the spotted owl association with structurally complex habitats containing high canopy closure was in part due to their intolerance of high temperatures. Complex vertically structured habitat such as mature and old-growth forests habitats contain sufficient cover to provides protection from predators (Franklin et al. 2000, p. 578-579).

Spotted owls nest almost exclusively in trees. Like roosts, nest sites are found in forests having complex structure dominated by large diameter trees and high canopy closure (Forsman et al. 1984, p. 30; Hershey et al. 1998, p. 1402, LaHaye et al. 1997, p. 46-48). Even in forests that have been previously logged, spotted owls select forests having a structure (i.e., larger trees, greater canopy closure) different than forests generally available to them (Folliard 1993, p. 40; Buchanan et al. 1995, p. 304-305; Hershey et al. 1998, p. 1406-1407). In eastern Washington,

spotted owl nest sites were found to have canopies of dominant and/or codominant and intermediate trees that were farther aboveground, more 35-60-cm (14-24 in)-dbh Douglas-fir *(Pseudotsuga menzies/,* greater basal area of Douglas-fir trees, more 61-84-cm (24-33.5 in) dbh ponderosa pine *(Pinus ponderosa)* trees, more live tree basal and more basal area of Class IV snags (broken snags with no branches and little bark).

Roost sites selected by spotted owls have more complex vegetation structure than forests generally available to them (Barrows and Barrows 1978, p. 2-3; Forsman et al. 1984, pp. 29-30; Solis and Gutiérrez 1990, pp. 742-743, 747). These habitats are usually multi-layered forests having high canopy closure and large diameter trees in the overstory.

Foraging habitat is the most variable of all habitats used by territorial spotted owls (Thomas et al. 1990; USDI FWS 2011b, p. G-2). Descriptions of foraging habitat have ranged from complex structure (Solis and Gutiérrez 1990, pp. 742-744) to a broader range of forests with lower canopy closure and smaller trees than forests containing nests or roosts (Gutiérrez 1996, p. 3-5). Foraging habitat for northern spotted owls provides a food supply for survival and reproduction. Foraging activity is positively associated with tree height diversity (North et al. 1999, p. 524), canopy closure and woody debris (Irwin et al. 2000, p. 180; Courtney et al. 2004, pp. 5-15), snag volume, density of snags greater than 20 in (50 cm) dbh (North et al. 1999, p. 524; Irwin et al. 2000, pp. 179-180; Courtney et al. 2004, pp. 5-15), density of trees greater than or equal to 31 in (80 cm) dbh (North et al. 1999, p. 524), volume of woody debris (Irwin et al. 2000, pp. 179-180), and young forests with some structural characteristics of old forests (Carey et al.1992, pp. 245-247; Irwin et al. 2000, pp. 178-179). Northern spotted owls select old forests for foraging in greater proportion than their availability at the landscape scale (Carey et al. 1992, pp. 236-237; Carey and Peeler 1995, p. 235; Forsman et al. 2004, pp. 372-373), but will forage in younger stands with high prey densities and access to prey (Carey et al. 1992, p. 247; Rosenberg and Anthony 1992, p. 165; Thome et al. 1999, pp. 56-57).

Dispersal habitat is essential to maintaining stable populations by filling territorial vacancies when resident northern spotted owls die or leave their territories, and to providing adequate gene flow across the range of the species. Dispersal habitat, at a minimum, consists of stands with adequate tree size and canopy closure to provide protection from avian predators and at least minimal foraging opportunities (USDI FWS 2011b, p. G-1). Dispersal habitat may include younger and less diverse forest stands than foraging habitat, such as even-aged, pole-sized stands, but such stands should contain some roosting structures and foraging habitat to allow for temporary resting and feeding for dispersing juveniles (USDI FWS 2011b, p. G-1). . In a study of the natal dispersal of northern spotted owls, Sovern and others (2015, pp. 257-260) found the majority of roosts were in forested habitats with at least some large (>50 cm or about 19 inches dbh) trees and they selected stands with high canopy cover (>70 percent) at the landscape scale. These authors suggested the concept of ‘dispersal’ habitat as a lower quality type of habitat may be inappropriate. Forsman et al. (2002, p. 22) found that spotted owls could disperse through highly fragmented forest landscapes. However, the stand-level and landscape-level attributes of forests needed to facilitate successful dispersal have not been thoroughly evaluated (Buchanan 2004, p. 1341).

Spotted owls may be found in younger forest stands that have the structural characteristics of older forests or retained structural elements from the previous forest. In redwood forests and mixed conifer-hardwood forests along the coast of northwestern California, considerable numbers of spotted owls also occur in younger forest stands, particularly in areas where hardwoods provide a multi-layered structure at an early age (Thomas et al. 1990, p. 158; Diller and Thome 1999, p. 275). In mixed conifer forests in the eastern Cascades in Washington, 27 percent of nest sites were in old-growth forests, 57 percent were in the understory reinitiation phase of stand development, and 17 percent were in the stem exclusion phase (Buchanan et al. 1995, p. 304). In the western Cascades of Oregon, 50 percent of spotted owl nests were in late-seral/old-growth stands (greater than 80 years old), and none were found in stands of less than 40 years old (Irwin et al. 2000, p. 41).

In the Western Washington Cascades, spotted owls roosted in mature forests dominated by trees greater than 50 centimeters (19.7 inches) dbh with greater than 60 percent canopy closure more often than expected for roosting during the non-breeding season. Spotted owls also used young forest (trees of 20 to 50 centimeters (7.9 inches to 19.7 inches) dbh with greater than 60 percent canopy closure) less often than expected based on this habitat's availability (Herter et al. 2002, p. 441).

In the Coast Ranges, Western Oregon Cascades and the Olympic Peninsula, radio-marked spotted owls selected for old-growth and mature forests for foraging and roosting and used young forests less than predicted based on availability (Forsman et al. 1984, pp. 24-25; Carey et al. 1990, pp. 14-15; Thomas et al. 1990; Forsman et al. 2005, pp. 372-373). Glenn et al. (2004, pp. 46-47) studied spotted owls in young forests in western Oregon and found little preference among age classes of young forest.

Habitat use is influenced by prey availability. Ward (1990, p. 62) found that spotted owls foraged in areas with lower variance in prey densities (that is, where the occurrence of prey was more predictable) within older forests and near ecotones of old forest and brush seral stages. Zabel et al. (1995, p. 436) showed that spotted owl home ranges are larger where flying squirrels (*Glaucomys sabrinus*) are the predominant prey and smaller where wood rats (*Neotoma* spp.) are the predominant prey. The availability or abundance of prey can in turn influence reproductive success (Rosenburg et al. 2003, pp. 1720-1723).

The availability and distribution of habitats are important considerations. Landscape-level analyses in portions of Oregon Coast and California Klamath provinces suggest that a mosaic of late-successional habitat interspersed with other seral conditions may benefit spotted owls more than large, homogeneous expanses of older forests (Zabel et al. 2003, p. 1038; Franklin et al. 2000, pp. 573-579; Meyer et al. 1998, p. 43). In Oregon Klamath and Western Oregon Cascade provinces, Dugger et al. (2005, p. 876) found that apparent survival and reproduction was positively associated with the proportion of older forest near the territory center (within 730 meters) (2,395 feet). Survival decreased dramatically when the amount of non-habitat (non-forest areas, sapling stands, etc.) exceeded approximately 50 percent of the home range (Dugger et al. 2005, pp. 873-874). The authors concluded that they found no support for either a positive or negative direct effect of intermediate-aged forest—that is, all forest stages between sapling and mature, with total canopy cover greater than 40 percent—on either the survival or

reproduction of spotted owls. It is unknown how these results were affected by the low habitat fitness potential in their study area, which Dugger et al. (2005, p. 876) stated was generally much lower than those in Franklin et al. (2000) and Olson et al. (2004), and the low reproductive rate and survival in their study area, which they reported were generally lower than those studied by Anthony et al. (2006). Olson et al. (2004, pp. 1050-1051) found that reproductive rates fluctuated biennially and were positively related to the amount of edge between late-seral and mid-seral forests and other habitat classes in the central Oregon Coast Range. Olson et al. (2004, pp. 1049-1050) concluded that their results indicate that while mid-seral and late-seral forests are important to spotted owls, a mixture of these forest types with younger forest and non-forest may be best for spotted owl survival and reproduction in their study area. In a large-scale demography modeling study, Forsman et al. (2011, pp. 1-2) found a positive correlation between the amount of suitable habitat and recruitment of young.

*Reproductive Biology*

The spotted owl is relatively long-lived, has a long reproductive life span, invests significantly in parental care, and exhibits high adult survivorship relative to other North American owls (Forsman et al. 1984; Gutiérrez et al. 1995, p. 5). Spotted owls are sexually mature at 1 year of age, but rarely breed until they are 2 to 5 years of age (Miller et al. 1985, p. 93; Franklin 1992, p. 821; Forsman et al. 2002, p. 17). Breeding females lay one to four eggs per clutch, with the average clutch size being two eggs; however, most spotted owl pairs do not nest every year, nor are nesting pairs successful every year (USDI FWS 1990b; Forsman et al. 1984, pp. 32-34; Anthony et al. 2006, p. 28), and re-nesting after a failed nesting attempt is rare (Gutiérrez 1996, p. 4). The small clutch size, temporal variability in nesting success, and delayed onset of breeding all contribute to the relatively low fecundity of this species (Gutiérrez 1996, p. 4).

Courtship behavior usually begins in February or March, and females typically lay eggs in late March or April. The timing of nesting and fledging varies with latitude and elevation (Forsman et al. 1984, p. 32). After they leave the nest in late May or June, juvenile spotted owls depend on their parents until they are able to fly and hunt on their own. Parental care continues after fledging into September (USDI FWS 1990a; Forsman et al. 1984, p. 38). During the first few weeks after the young leave the nest, the adults often roost with them during the day. By late summer, the adults are rarely found roosting with their young and usually only visit the juveniles to feed them at night (Forsman et al. 1984, p. 38). Telemetry and genetic studies indicate that close inbreeding between siblings or parents and their offspring is rare (Haig et al. 2001, p. 35; Forsman et al. 2002, p. 18). Hybridization of northern spotted owls with California spotted owls and barred owls has been confirmed through genetic research (Hamer et al. 1994, pp. 487-492; Gutiérrez et al. 1995, pp. 2-3; Dark et al. 1998, p. 52; Kelly 2001, pp. 33-35; Funk et al. 2008, pp. 161-171).

*Dispersal Biology*

Natal dispersal of spotted owls typically occurs in September and October with a few individuals dispersing in November and December (Miller et al. 1997; Forsman et al. 2002, p. 13). Natal dispersal occurs in stages, with juveniles settling in temporary home ranges between bouts of dispersal (Forsman et al. 2002, pp. 13-14; Miller et al. 1997, p. 143). The median natal dispersal

distance is about 10 miles for males and 15.5 miles for females (Forsman et al. 2002, p. 16). Dispersing juvenile spotted owls experience high mortality rates, exceeding 70 percent in some studies (USDI FWS 1990a; Miller 1989, pp. 32-41). Known or suspected causes of mortality during dispersal include starvation, predation, and accidents (Miller 1989, pp. 41-44; USDI FWS 1990a; Forsman et al. 2002, pp. 18-19). Parasitic infection may contribute to these causes of mortality, but the relationship between parasite loads and survival is poorly understood (Hoberg et al. 1989, p. 247; Gutiérrez 1989, pp. 616-617; Forsman et al. 2002, pp. 18-19). Successful dispersal of juvenile spotted owls may depend on their ability to locate unoccupied suitable habitat in close proximity to other occupied sites (LaHaye et al. 2001, pp. 697-698).

There is little evidence that small openings in forest habitat influence the dispersal of spotted owls, but large, non-forested valleys such as the Willamette Valley apparently are barriers to both natal and breeding dispersal (Forsman et al. 2002, p. 22). The degree to which water bodies, such as the Columbia River and Puget Sound, function as barriers to dispersal is unclear, although radio telemetry data indicate that spotted owls move around large water bodies rather than cross them (Forsman et al. 2002, p. 22). Analysis of the genetic structure of spotted owl populations suggests that gene flow may have been adequate between the Olympic Mountains and the Washington Cascades, and between the Olympic Mountains and the Oregon Coast Range (Haig et al. 2001, p. 35).

Breeding dispersal occurs among a small proportion of adult spotted owls; these movements were more frequent among females and unmated individuals (Forsman et al. 2002, pp. 20-21). Breeding dispersal distances were shorter than natal dispersal distances and also are apparently random in direction (Forsman et al. 2002, pp. 21-22). In California spotted owls, a similar subspecies, the probability for dispersal was higher in younger owls, single owls, paired owls that lost mates, owls at low quality sites, and owls that failed to reproduce in the preceding year (Blakesley et al. 2006, p.77). Both males and females dispersed at near equal distances (Blakesley et al. 2006, p. 76). In 72 percent of observed cases of dispersal, dispersal resulted in increased habitat quality (Blakesley et al. 2006, p. 77).

Dispersal can also be described as having two phases: transience and colonization (Courtney et al 2004, p. 5-13). Fragmented forest landscapes are more likely to be used by owls in the transience phase as a means to move rapidly between denser forest areas (Courtney et al 2004, p. 5-13; USDI FWS 2012a, p. 14086). Movements through mature and old growth forests occur during the colonization phase when birds are looking to become established in an area (Miller et al 1997, p. 144; Courtney et al 2004, p. 5-13). Transient dispersers use a wider variety of forest conditions for movements than colonizing dispersers, who require habitats resembling nesting/roosting/foraging habitats used by breeding birds (USDI FWS 2012a, p. 14086). Dispersal success is likely highest in mature and old growth forest stands where there is more likely to be adequate cover and food supply (USDI FWS 2012a, p. 14086).

*Food Habits*

Spotted owls are mostly nocturnal, although they also forage opportunistically during the day (Forsman et al. 1984, p. 51; 2004, pp. 222-223; Sovern et al. 1994, p. 202). The composition of the spotted owl's diet varies geographically and by forest type. Generally, flying squirrels

(*Glaucomys sabrinus*) are the most prominent prey for spotted owls in Douglas-fir and western hemlock (*Tsuga heterophylla*) forests (Forsman et al. 1984, pp. 40-41) in Washington and Oregon, while dusky-footed wood rats (*Neotoma fuscipes*) are a major part of the diet in the Oregon Klamath, California Klamath, and California Coastal provinces (Forsman et al. 1984, pp. 40-42; 2004, p. 218; Ward et al. 1998, p. 84; Hamer et al. 2001, p. 224). Depending on location, other important prey include deer mice (*Peromyscus maniculatus*), tree voles (*Arborimus longicaudus, A. pomo*), red-backed voles (*Clethrionomys* spp.), gophers (*Thomomys* spp.), snowshoe hare (*Lepus americanus*), bushy-tailed wood rats (*Neotoma cinerea*), birds, and insects, although these species comprise a small portion of the spotted owl diet (Forsman et al. 1984, pp. 40-43; 2004, p. 218; Ward et al. 1998; p. 84; Hamer et al. 2001, p.224).

Other prey species such as the red tree vole (*Arborimus longicaudus),* red-backed voles (*Clethrionomys gapperi),* mice, rabbits and hares, birds, and insects) may be seasonally or locally important (reviewed by Courtney et al. 2004, pp. 4-27). For example, Rosenberg et al. (2003, p. 1720) showed a strong correlation between annual reproductive success of spotted owls (number of young per territory) and abundance of deer mice (*Peromyscus maniculatus*) (r2 = 0.68), despite the fact they only made up 1.6±0.5 percent of the biomass consumed. However, it is unclear if the causative factor behind this correlation was prey abundance or a synergistic response to weather (Rosenberg et al. 2003, p. 1723). Ward (1990, p. 55) also noted that mice were more abundant in areas selected for foraging by owls. Nonetheless, spotted owls deliver larger prey to the nest and eat smaller food items to reduce foraging energy costs; therefore, the importance of smaller prey items, like *Peromyscus*, in the spotted owl diet should not be underestimated (Forsman et al. 2001, p. 148; 2004, pp. 218-219). In the southern portion of their range, where woodrats are a major component of their diet, northern spotted owls are more likely to use a variety of stands, including younger stands, brushy openings in older stands, and edges between forest types in response to higher prey density in some of these areas (Forsman et al. 1984, pp. 24-29).

*Population Dynamics*

The northern spotted owl is relatively long-lived, has a long reproductive life span, invests significantly in parental care, and exhibits high adult survivorship relative to other North American owls (Forsman et al. 1984; Gutiérrez et al. 1995, p. 5). The spotted owl's long reproductive life span allows for some eventual recruitment of offspring, even if recruitment does not occur each year (Franklin et al. 2000, p. 576).

Annual variation in population parameters for spotted owls has been linked to environmental influences at various life history stages (Franklin et al. 2000, p. 581). In coniferous forests, mean fledgling production of the California spotted owl (*Strix occidentalis occidentalis*), a closely related subspecies, was higher when minimum spring temperatures were higher (North et al. 2000, p. 805), a relationship that may be a function of increased prey availability. Across their range, spotted owls have previously shown an unexplained pattern of alternating years of high and low reproduction, with highest reproduction occurring during even-numbered years (e.g., Franklin et al. 1999, p. 1). Annual variation in breeding may be related to weather (i.e., temperature and precipitation) (Wagner et al. 1996, p. 74; Zabel et al. 1996, p.81 *In*: Forsman et al. 1996) and fluctuation in prey abundance (Zabel et al. 1996, pp.437-438).

A variety of factors may regulate spotted owl population levels. These factors may be density-dependent (e.g., habitat quality, habitat abundance) or density-independent (e.g., climate). Interactions may occur among factors. For example, as habitat quality decreases, density-independent factors may have more influence on survival and reproduction, which tends to increase variation in the rate of growth (Franklin et al. 2000, pp. 581-582). Specifically, weather could have increased negative effects on spotted owl fitness for those owls occurring in relatively lower quality habitat (Franklin et al. 2000, pp. 581-582). A consequence of this pattern is that at some point, lower habitat quality may cause the population to be unregulated (have negative growth) and decline to extinction (Franklin et al. 2000, p. 583). Recent findings of the northern spotted owl meta-analysis suggest that competition with barred owls is an important stressor of spotted owl populations, but habitat availability and climatic patterns also appear to influence survival, occupancy, recruitment, and, to a lesser extent, fecundity (Dugger et al. 2016, entire). Authors noted variable annual rates of decline across the range, but the CleElum study area in Washington and the control area in Green Diamond study area in northern California showed the highest annual rates of population decline (Dugger et al. 2016, pp.70-71; further detail provided in *Barred Owls* section below). Rangewide, the weighted mean estimated population was determined to decline 3.8 percent per year (Dugger et al. 2016, p. 71).

Olson et al. (2005, pp. 930-931) used open population modeling of site occupancy that incorporated imperfect and variable detectability of spotted owls and allowed modeling of temporal variation in site occupancy, extinction, and colonization probabilities (at the site scale). The authors found that visit detection probabilities average less than 0.70 and were highly variable among study years and among their three study areas in Oregon. Pair site occupancy probabilities declined greatly on one study area and slightly on the other two areas. However, for all owls, including singles and pairs, site occupancy was mostly stable through time. Barred owl presence had a negative effect on these parameters (see barred owl discussion in the New Threats section below). However, there was enough temporal and spatial variability in detection rates to indicate that more visits would be needed in some years and in some areas, especially if establishing pair occupancy was the primary goal.

**Threats**

The spotted owl was listed as threatened throughout its range "due to loss and adverse modification of suitable habitat as a result of timber harvesting and exacerbated by catastrophic events such as fire, volcanic eruption, and wind storms" (USDI FWS 1990a, p. 26114). More specifically, threats to the spotted owl included low populations, declining populations, limited habitat, declining habitat, inadequate distribution of habitat or populations, isolation of provinces, predation and competition, lack of coordinated conservation measures, and vulnerability to natural disturbance (USDI FWS 1992a, pp. 33-41). These threats were characterized for each province as severe, moderate, low, or unknown (USDI FWS 1992a, pp. 33-41). Declining habitat was recognized as a severe or moderate threat to the spotted owl throughout its range, isolation of populations was identified as a severe or moderate threat in 11 provinces, and a decline in population was a severe or moderate threat in 10 provinces. Together, these three factors represented the greatest concerns about rangewide conservation of the spotted owl. Limited habitat was considered a severe or moderate threat in nine provinces,

and low populations were a severe or moderate concern in eight provinces, suggesting that these factors were also a concern throughout the majority of the spotted owl's range. Vulnerability to natural disturbances was rated as low in five provinces.

The degree to which predation and competition might pose a threat to the spotted owl was unknown in more provinces than any of the other threats, indicating a need for additional information. Few empirical studies exist to confirm that habitat fragmentation contributes to increased levels of predation on spotted owls (Courtney et al. 2004, pp. 11-8 to 11-9). However, great horned owls (*Bubo virginianus*), an effective predator on spotted owls, are closely associated with fragmented forests, openings, and clearcuts (Johnson 1992, p. 84; Laidig and Dobkin 1995, p. 155). As mature forests are harvested, great horned owls may colonize fragmented forests, thereby increasing spotted owl vulnerability to predation.

The Service conducted a 5-year review of the spotted owl in 1994 (USDI FWS 2004), for which the Service prepared a scientific evaluation of the status of the spotted owl (Courtney et al. 2004). An analysis was conducted assessing how the threats described in 1990 might have changed by 2004. Some of the key threats identified in 2004 were:

- "Although we are certain that current harvest effects are reduced, and that past harvest is also probably having a reduced effect now as compared to 1990, we are still unable to fully evaluate the current levels of threat posed by harvest because of the potential for lag effects…In their questionnaire responses…6 of 8 panel member identified past habitat loss due to timber harvest as a current threat, but only 4 viewed current harvest as a present threat" (Courtney and Gutiérrez 2004, pp.11-7).

- "Currently the primary source of habitat loss is catastrophic wildfire, although the total amount of habitat affected by wildfires has been small (a total of 2.3 percent of the range-wide habitat base over a 10-year period)" (Courtney and Gutiérrez 2004, pp.11-8).

- "Although the panel had strong differences of opinion on the conclusiveness of some of the evidence suggesting [barred owl] displacement of [spotted owls], and the mechanisms by which this might be occurring, there was no disagreement that [barred owls] represented an operational threat. In the questionnaire, all 8 panel members identified [barred owls] as a current threat, and also expressed concern about future trends in [barred owl] populations" (Courtney and Gutiérrez 2004, pp. 11-8).

Threats, as identified in the 2011 Revised Recovery Plan for the Northern Spotted Owl, continue to emphasize that habitat loss and barred owls are the main threats to northern spotted owl recovery (USDI FWS 2011b, Appendix A), and that effects of high severity wildfires pose concern for habitat conservation in some portions of the range (Davis et al. 2016, p. 38).

*Barred Owls (Strix varia)*

Barred owls currently appear to be the primary threat to northern spotted owls. With its recent expansion to as far south as Marin County, California (Gutiérrez et al. 2004, pp. 7-12 to 7-13; Steger et al. 2006, p.226), the barred owl's range now completely overlaps that of the northern spotted owl. Evidence that barred owls are occurring in higher densities than spotted owls in

many parts of the range (3–8 barred owl territories/northern spotted owl; Hamer et al. 2007; Singleton et al. 2010; Wiens et al. 2011, 2014), and, to a lesser extent, northern California spotted owls (Diller et al. 2016, Dugger et al. 2016). In a recent study, the highest densities found were in the Oregon Coast Range, with up to 20 barred owls per spotted owl territory reported (Wiens et al. 2017, p. 12).

The two species of owls share similar habitats and are likely competing for food resources (Hamer et al. 2001, p. 226, Gutiérrez et al. 2007, p. 187; Livezey and Fleming 2007, p. 319, Wiens et al., 2014, pp. 24 and 33). Hamer found a strong diet overlap (76 percent) between northern spotted and barred owl diets (pp. 221, 226). Barred owl diets are more diverse than northern spotted owl diets and include species associated with riparian and other moist habitats (e.g. fish, invertebrates, frogs, and crayfish), along with more terrestrial and diurnal species (Smith et al. 1983; Hamer et al. 2001; Gronau 2005, Wiens et al., 2014, p. 24). Even though barred owls may be taking northern spotted owls' primary prey only as a generalist, northern spotted owls may be affected by a sufficient reduction in the density of these prey items due to barred owls, leading to a depletion of prey to the extent that the northern spotted owl cannot find an adequate amount of food to sustain maintenance or reproduction (Gutiérrez et al. 2007, p. 187; Livezey and Fleming 2007, p. 319). These impacts are likely to have direct and indirect effects on ecosystem processes (Holm et al. 2017, p. 618)

In addition to completion for prey, barred owls are competing for habitats (Hamer et al. 1989, p.55; Dunbar et al. 1991, p. 467; Herter and Hicks 2000, p. 285; Pearson and Livezey 2003, p. 274; Wiens et al., 2014, pp. 24 and 33). Barred owls were initially thought to be more closely associated with early successional forests than spotted owls, based on studies conducted on the west slope of the Cascades in Washington (Hamer et al 1989, p. 34; Iverson 1993, p.39). However, more recent studies conducted in the Pacific Northwest show that barred owls frequently use mature and old-growth forests (Pearson and Livezey 2003, p. 270; Gremel 2005, Schmidt 2006, p. 1; Singleton et al. 2010, pp. 290-292). In the fire prone forests of eastern Washington, a telemetry study conducted on barred and spotted owls showed that barred owl home ranges were located on lower slopes or valley bottoms, in closed canopy, mature, Douglas-fir forest, while spotted owl sites were located on mid-elevation areas with southern or western exposure, characterized by closed canopy, mature, ponderosa pine or Douglas-fir forest (Singleton et al. 2005, p. 1).

In addition to resource competition, barred owls have been documented to physically attack spotted owls (Pearson and Livezey 2003, p. 274), and circumstantial evidence strongly indicated that a barred owl killed a spotted owl (Leskiw and Gutiérrez 1998, p. 226).

There is consensus in the literature on the negative influence barred owls are having on northern spotted owl site occupancy, fecundity, reproduction, apparent survival, and detectability, and that data indicates that over the last ten-fifteen years, they are contributing to declines in spotted owl populations (Olson et al. 2005, p. 924; Forsman et al. 2011, pp. 69-70), Dugger et al. 2011, pp. 2463-2467; Dugger et al. 2016, pp. 70-96). As barred owls have expanded, the occupancy of historical spotted owl territories appears to be declining. Over ten years ago, site occupancy of spotted owls in Washington and Oregon was significantly lower ($p < 0.001$) after barred owls were detected within 0.8 kilometer (0.5 miles) of the territory center but was "only marginally lower" ($p = 0.06$) if barred owls were located more than 0.8 kilometer (0.5 miles) from the spotted owl territory center (Kelly et al. 2003, p. 51). Pearson and Livezey (2003, p. 271) found

that there were significantly more barred owl site-centers in unoccupied spotted owl circles than occupied spotted owl circles (centered on historical spotted owl site-centers) with radii of 0.8 kilometer (0.5 miles) ($p = 0.001$), 1.6 kilometer (1 mile) ($p = 0.049$), and 2.9 kilometer (1.8 miles) ($p = 0.005$) in Gifford Pinchot National Forest. In Olympic National Park, Gremel (2005, p. 11) found a significant decline ($p = 0.01$) in spotted owl pair occupancy at sites where barred owls had been detected, while pair occupancy remained stable at spotted owl sites without barred owls. Olson et al. (2005, p. 928) found that the annual probability that a spotted owl territory would be occupied by a pair of spotted owls after barred owls were detected at the site declined by 5 percent in the HJ Andrews study area, 12 percent in the Coast Range study area, and 15 percent in the Tyee study area. In contrast, Bailey et al. (2009, p. 2983), when using a two-species occupancy model, showed no evidence that barred owls excluded northern spotted owls from territories in Oregon. More recently, results from a barred owl and northern spotted owl radio-telemetry study in Washington reported two northern spotted owls fleeing their territories and traveling six and 15 miles, believed to be as a result of frequent direct encounters with barred owls; both northern spotted owls were subsequently found dead (Irwin et al. 2010, p. 3-4). Preliminary findings from an ongoing barred owl experimental control/treatment study, spotted owl pair occupancy was low, has declined in control sites; while (with the exception of one year in one study area), the occupancy by barred owls has increased (Wiens et al. 2017, tables 1 and 2). Authors also report that the probability of use by barred owls within 500 acre hexagons (1,235 acres) in the Oregon Coast Ranges study area was high in the two years of the study in the control area (>0.920) (p. 16).

Numerous studies suggest that barred owls are negatively affecting spotted owl survival and reproduction. Anthony et al. (2006, p. 32) found significant evidence for negative effects of barred owls on apparent survival of spotted owls in two of 14 study areas (Olympic and Wenatchee). They attributed the equivocal results for most of their study areas to the coarse nature of their barred owl covariate. Dugger et al. (2011, pp. 2463-2467) described synergistic effects associated with territory composition and presence of barred owls; some northern spotted owl pairs retained their territories and continued to survive and successfully reproduce during their study even when barred owls were present, but the effects of reduced old growth forest in the core habitat areas were compounded when barred owls were present - extinction rates of northern spotted owl territories nearly tripled when barred owls were detected. Yackulic and others documented similar findings; the effects of interspecific competition were likely to negatively affect spotted owls, both through its immediate effects on local extinction and by indirectly lowering colonization (Yackulic et al., 2014, pp. 271-273).

Most recently, apparent survival and local extinction rates were the key vital rates associated with barred owl presence in spotted owl populations (Dugger et al., 2016, p. 93-98). Dugger et al. (2016, pp. 98-99) suggested that barred owl densities may now be high enough across the range of the northern spotted owl that, despite the continued management and conservation of suitable owl habitat on Federal lands (Davis et al. 2011, 2015), the long-term prognosis for the persistence of northern spotted owls may be in question without additional management intervention. For example, Dugger et al. (2016) found that the removal of barred owls in the Green Diamond study area in northern California had rapid, positive effects on northern spotted owl survival and rates of population change, suggesting that, along with habitat conservation and

management, barred owl removal may be able to slow or reverse northern spotted owl population declines on at least a localized scale (Diller et al. 2016).

Olson et al. (2004, p. 1048) found that the presence of barred owls had a significant negative effect on the reproduction of spotted owls in the central Coast Range of Oregon (in the Roseburg study area). The conclusion that barred owls had no significant effect on the reproduction of spotted owls in one study (Iverson 2004, p. 89) was unfounded because of small sample sizes (Livezey 2005, p. 102). It is likely that all of the above analyses underestimated the effects of barred owls on the reproduction of spotted owls because spotted owls often cannot be relocated after they are displaced by barred owls (Forsman, E. pers. comm. 2006, cited in USDI FWS 2011b, p. B-11). Anthony et al. (2006, p. 32) found significant evidence for negative effects of barred owls on apparent survival of spotted owls in two of 14 study areas (Olympic and Wenatchee). They attributed the equivocal results for most of their study areas to the coarse nature of their barred owl covariate. Dugger et al. (2011, pp. 2463-2467) confirmed the synergistic effects of barred owls and territory habitat characteristics on extinction and colonization rates of territories by northern spotted owls. Extinction rates of northern spotted owl territories nearly tripled when barred owls were detected (Dugger et al. 2011, p. 2464). The recent meta-analysis suggested weak relationships between fecundity and barred owls across all study areas; however, declines in the number of occupied spotted owl sites contributed to declines in the total number of young produced per study area (Dugger et al. 2016 p. 96).

Monitoring and management of northern spotted owls has become more complicated due to their possible reduced detectability when barred owls are present (Kelly et al. 2003, pp. 51-52; Courtney et al. 2004, p. 7-16 ; Olson et al. 2005, p. 929; Crozier et al. 2006, p.766-767). Evidence that northern spotted owls were responding less frequently during surveys led the Service and its many research partners to update the northern spotted owl survey protocol (USDI FWS 2012b). The recent changes to the northern spotted owl survey protocol were based on the probability of detecting northern spotted owls when barred owls are present (See USDI FWS Memorandum, revised January 9, 2012, "Northern Spotted Owl Survey Protocol" and attached "Protocol for Surveying Proposed Management Activities That May Impact Northern Spotted Owls" for guidance and methodology).

In an analysis of more than 9,000 banded spotted owls throughout their range, only 47 hybrids were detected (Kelly and Forsman 2004, p. 807). Consequently, hybridization with the barred owl is considered to be "an interesting biological phenomenon that is probably inconsequential, compared with the real threat—direct competition between the two species for food and space" (Kelly and Forsman 2004, p. 808).

There is no evidence that the increasing trend in barred owls has stabilized in any portion of the spotted owl's range in the western United States, and "there are no grounds for optimistic views suggesting that barred owl impacts on northern spotted owls have been already fully realized" (Gutiérrez et al. 2004, pp. 7-38). To date, this situation does not appear to have changed.

*Wildfire*

At the time of listing there was recognition that large-scale wildfire posed a threat to the spotted owl and its habitat (USDI FWS 1990a, p. 26183). New information suggests fire may be more of a threat than previously thought. In 2005 the overall total amount of habitat affected by wildfires was been relatively small (Lint 2005, p. v) but since then, there have been significant losses of nesting/roosting habitats reported, particularly in the reserved land allocations of the Klamath Province and parts of the Oregon Cascades (Davis et al. 2011, pp. 43-48; Davis et al. 2016, tables 5 and 7). Table A-2 below also summarizes habitat lost from natural disturbances, the majority of which has resulted from high severity fires. Silvicultural management of forest fuels are currently being implemented throughout the spotted owl's range, in an attempt to reduce the levels of fuels that have accumulated during nearly 100 years of effective fire suppression; however, the ability to protect spotted owl habitat and viable populations of spotted owls from large fires through risk-reduction endeavors is uncertain (Courtney et al. 2004, pp. 12-11). The NWFP recognized wildfire as an inherent part of managing spotted owl habitat in certain portions of the range. The distribution and size of reserve blocks as part of the NWFP design may help mitigate the risks associated with large-scale fire (Lint 2005, p. 77).

Studies indicate that the effects of wildfire on spotted owls and their habitat are variable, depending on fire intensity, severity, and size. Within the fire-adapted forests of the spotted owl's range, spotted owls likely have adapted to withstand fires of variable sizes and severities. However, fire is often considered a primary threat to spotted owls because of its potential to alter habitat rapidly (Bond et al. 2009, p. 1116) and is a major cause of habitat loss on Federal lands (Courtney et al. 2004, executive summary; Davis et al. 2011, pp. 43-48; Davis et al. 2016, tables 5 and 7).

Research results on spotted owl use of burned landscapes and their demographic variables following fires at localized scales has yielded variable results that were influenced by small sample sizes, varying impacts to habitat, existing forest management practices, the condition of pre- and post-fire landscapes, and the status of spotted owls that previously occupied the sites (Elliott 1985; Gaines et al. 1997, King et al. 1998; Bond et al. 2002; Jenness et al. 2004; Clark 2007; Seamans and Gutierrez 2007; Bond et al. 2009; Clark et al. 2011; Roberts et al. 2011; Clark et al. 2013; Comfort 2014; Lee and Bond 2015a; Lee and Bond 2015b; Bond et al. 2016; and Jones et al., 2016). Bond and others (2002) examined the demography of the three spotted owl subspecies after wildfires, in which wildfire burned through spotted owl nest and roost sites in varying degrees of severity. Post-fire demography parameters for the three subspecies were similar or better than long-term demographic parameters for each of the three subspecies in those same areas (Bond et al. 2002, p. 1025-1026). In a preliminary study conducted by Anthony and Andrews (2004, p. 8) in the Oregon Klamath Province, their sample of spotted owls appeared to be using a variety of habitats within the area of the Timbered Rock fire, including areas where burning had been moderate. Site fidelity can influence spotted owl use of burned areas that were previously suitable (Clark 2007, Bond et al. 2009, Lee et al. 2012). Also, the amount, extent, and location of high severity fires appear to be strong influences on spotted owl occupancy. One year following the extensive King Fire in the Sierra Nevada Mountains, Jones and others (2016) documented strong negative California spotted owl population impacts, with declines in occupancy and reproduction associated with severely burned sites; the probability of site extinction in that study was seven times higher one year after the fire where more than 50

percent of the site (approximately 0.7 mile radius area) burned at high severity (75–100 percent canopy mortality) (p. 303-304).

In southwest Oregon, lower occupancy and survival rates of spotted owl were found in burned areas compared to unburned, but the results were confounded by prior management and post-fire harvest (Clark 2007, Clark et al. 2011, Lee et al. 2012, Clark et al. 2013). Available data on the direct mortality of spotted owls from fire is limited. In one study, mortality was assumed to have occurred at one site, and spotted owls were present at only one of the six sites 1 year after a fire (Gaines et al. 1997, p. 126). In 1994, two wildfires burned in the Yakama Indian Reservation in Washington's eastern Cascades, affecting the home ranges of two radio-tagged spotted owls (King et al. 1998, pp. 2-3). No direct mortality of spotted owls was observed, even though thick smoke covered several spotted owl site-centers for a week. Although the amount of home ranges burned was not quantified, spotted owls were observed using areas that burned at low and medium intensities. More research is needed to understand further the relationship between fire and spotted owl habitat use. Overall, we can conclude that fires are a change agent for northern spotted owl habitat, but there are still many unknowns regarding how much fire benefits or adversely affects northern spotted owl habitat (USDI FWS 2011b, p. III-31).

Additional impacts to northern spotted owls related to wildfire include forest management that occurs after fires. Post-fire salvage logging typically occurs on the majority of private timberlands, but also occurs on Federal lands to a smaller degree. This type of harvest can directly impact habitat potentially occupied by northern spotted owls and can negatively influence ecological processes, which can impair the long-term development of spotted owl habitat (reviewed in USDI FWS 2011b, p. III-48). Action agencies, working with the Service, are attempting to influence fire severity by designing projects to reduce fire-suppressed vegetation and mimic the effects of historical fire regimes. The effects of this type of management are uncertain and highly debated in the literature (Courtney et al. 2004, pp. 12-11, Omi and Martenson 2002, pp. 19-27; Irwin et al. 2004, p. 21; Spies et al. 2006 p. 359-361; Hanson et al. 2009, pp. 1316-1319; Spies et al. 2009, pp. 331-332; Ager et al. 2012, p. 282; Odion et al. 2014a pp. 10-12, Spies et al. 2012, pp. 10-12; Odion et al. 2014b, pp. 46-49; Gaines et al. 2010, Baker 2015, entire; Baker 2017, entire; Gallagher et al. 2018, pp. 10-13).

*West Nile Virus*

West Nile virus (WNV), caused by a virus in the family Flaviviridae, has killed millions of wild birds in North America since it arrived in 1999 (McLean et al. 2001; Caffrey 2003; Caffrey and Peterson 2003, pp. 7-8; Marra et al. 2004, p. 393). Mosquitoes are the primary carriers (vectors) of the virus that causes encephalitis in humans, horses, and birds. Mammalian prey may also play a role in spreading WNV among predators, like spotted owls. Owls and other predators of mice can contract the disease by eating infected prey (Garmendia et al. 2000, p. 3111; Komar et al. 2001). One captive spotted owl in Ontario, Canada, is known to have contracted WNV and died.

Human activities and landscape physiography appear to influence the occurrence of WNV (Dobson and Foufopoulos 2001, p. 1004; Gibbs et al. 2006, p. 80). Mountainous terrain typically associated with northern spotted owls may limit the widespread occurrence of WNV. The effect of how WNV will ultimately affect spotted owl populations is unknown but localized

populations could be adversely affected (Blakesley and others 2004, *in* Courtney et al. 2004, p. 8-25-8-31). Susceptibility to infection and the mortality rates of infected individuals vary among bird species (Blakesley et al. 2004, pp. 8-33), but most owls appear to be quite susceptible. For example, breeding Eastern screech owls (*Megascops asio*) in Ohio experienced 100 percent mortality (Grubb, T. pers. comm. 2006 cited in Blakesley et al. 2004, pp. 8-33). Barred owls, in contrast, showed lower susceptibility (Hunter, B. pers. comm. no date cited in Blakesley et al. 2004, pp. 8-34). Some level of innate resistance may occur (Fitzgerald et al. 2003), which could explain observations in several species of markedly lower mortality in the second year of exposure to WNV (Caffrey and Peterson 2003). Wild birds also develop resistance to WNV through immune responses (Deubel et al. 2001). The effects of WNV on bird populations at a regional scale have not been large, even for susceptible species (Caffrey and Peterson 2003), perhaps due to the short-term and patchy distribution of mortality (McGowan, K. pers. comm. no date, cited in Courtney et al. 2004) or annual changes in vector abundance and distribution.

Blakesley et al. (2004, pp. 8-35) offer competing propositions for the likely outcome of spotted owl populations being infected by WNV. One scenario is that spotted owls can tolerate severe, short-term population reductions due to WNV, because spotted owl populations are widely distributed and number in the several hundreds to thousands. An alternative scenario is that WNV will cause unsustainable mortality, due to the frequency and/or magnitude of infection, thereby resulting in long-term population declines and extirpation from parts of the spotted owl's current range. Thus far, no mortality in wild, northern spotted owls has been recorded; however, WNV is a potential threat of uncertain magnitude and effect (Blakesley et al. 2004, pp. 8-34).

*Sudden Oak Death*

Sudden oak death was not listed as particular threat at the time of listing but was recognized as a potential threat to the spotted owl after it was discovered in Oregon (Courtney et al. 2004, USDI Fish and Wildlife 2011). This disease is caused by the fungus-like pathogen, *Phytopthora ramorum* that was recently introduced from Europe and is rapidly spreading as it is capable of infecting over 100 species of trees and shrubs (APHIS 2011, in Peterson et al. 2015, p. 937) . The disease has been found in several different forest types and at elevations from sea level to over 800 m and is now known to extend over 650 km from south of Big Sur, California to Curry County, Oregon (Rizzo and Garbelotto 2003, p. 198). In some areas it has reached epidemic proportions in oak (Quercus spp.) and tanoak (*Lithocarpus densiflorus*) forests along approximately 300 kilometers (186 miles) of the central and northern California coast (Rizzo et al. 2002, p. 733). Near Brookings, Oregon it has killed tanoak and causing dieback of closely associated wild rhododendron (*Rhododendron* spp.) and evergreen huckleberry (*Vaccinium ovatum*) (Goheen et al. 2002, p. 441), common components of spotted owl habitat. Despite treatments of infected sites that remove all infected trees and shrubs as well as those occurring within a 300 foot buffer, occurrences of infected sites have increased since 2001 (Peterson et al. 2015, p. 937). The majority of infected sites in Oregon are concentrated in the Chetco River drainage, but it has been located as far north as Cape Sebastian (Peterson et al. 2015, p. 238). The spores from this pathogen are transmitted through the coastal fog and rain or through contaminated surfaces. During a study completed between 2001 and 2003 in California, one-third to one-half of the hiker's present in the study area carried infected soil on their shoes (Davidson et al. 2005, p. 587), creating the potential for rapid spread of the disease. Sudden oak

death poses a threat of uncertain proportion because of its potential impact on forest dynamics and alteration of key prey and spotted owl habitat components (e.g., hardwood trees, forest structure and nest tree mortality); especially in the southern portion of the spotted owl's range (Courtney et al. 2004, pp. 6-26 through 6-27, 11-8). Eradication treatments themselves have the potential to remove habitat at the stand level as all hardwoods and shrubs identified as carriers are removed. Because of the coastal influence on this pathogen, sudden oak death is not likely to be of consequence rangewide, but could compound existing stressors in coastal provinces of the spotted owl range.

*Inbreeding Depression, Genetic Isolation, and Reduced Genetic Diversity*
Inbreeding and other genetic problems due to small population sizes were not considered an imminent threat to the spotted owl at the time of listing. Earlier studies showed no indication of reduced genetic variation and past bottlenecks in Washington, Oregon, or California (Barrowclough et al. 1999, p. 922; Haig et al. 2004, p. 36). A more recent study however, reported a significant bottleneck influence in the Washington Cascades, an area known to be experiencing a significant population decline, and that other areas with significant population bottlenecks were correlated with declines in population growth rate (Funk et al. 2010, as reviewed in Haig et al. 2016, p. 187). Canadian populations may be more adversely affected by issues related to small population size including inbreeding depression, genetic isolation, and reduced genetic diversity (Courtney et al. 2004, pp. 11-9). A 2004 study (Harestad et al. 2004, p. 13) indicates that the Canadian breeding population was estimated to be less than 33 pairs and annual population decline may be as high as 35 percent. In 2007, a recommendation was made by the Spotted Owl Population Enhancement Team to remove northern spotted owls from the wild in British Columbia (USDI FWS 2012a, p. 14078). This recommendation resulted in the eventual capture of the remaining 16 wild northern spotted owls in British Columbia for a captive breeding program (USDI FWS 2012a, p. 14078). Low and persistently declining populations throughout the northern portion of the species range (see "Population Trends" below) may be at increased risk of losing genetic diversity.
Hybridization of northern spotted owls with California spotted owls, Mexican spotted owls, and barred owls has been confirmed through genetic research (Funk et al. 2008, p. 1; Hamer et al. 1994, p. 487; Gutiérrez et al. 1995, p. 3; Dark et al. 1998, p. 50; Kelly 2001, pp. 33-35).

*Climate Change*

Global climate change has the potential to produce entirely new environmental conditions, making predictions about future ecological consequences a more daunting challenge. Recent forecasts indicate that climate change will have long-term and variable impacts on forest habitat at local and regional scales. Locally, this could involve shifts in tree species composition that influence habitat suitability. Frey et al. (2016, pp. 1, 6) concluded that old-growth will provide some buffer from impacts of regional warming and/or slow the rate at which some species relying on old-growth must adapt, based on their modeling of the fine-scale spatial distribution, under-canopy air temperatures in mountainous terrain of central Oregon. Similarly, Lesmeister et al. (2019, p. 16) concluded that older forest can serve as a buffer to climate change and associated increases in wildfire, as these areas have the highest probability of persisting through fire events even in weather conditions associated with high fire activity. Regionally, there could

be losses of habitat availability caused by advances or retreats of entire vegetative communities, and perhaps prey communities as well. Effects of climate change, including fire and pest incidence, will not only affect currently suitable habitat for the northern spotted owl, they will also likely alter or interrupt forest growth and development processes (Karl et al. 2008, pp. 15 and 18; Dale et al. 2001, entire; Yospin et al. 2015, entire) that influence forest turnover rates and the emergence of suitable habitat attributes in new locations. These changes are predicted to be driven by changes in patterns of temperature and precipitation that are projected to occur under climate change scenarios (Mote et al. 2014, entire).

Glenn et al. (2010, p.2551) noted that the potential consequences of global climate change on Pacific Northwest forests remain somewhat unclear, though there is potential for changes in forest composition and disturbance patterns that could affect northern spotted owl populations. Most models predict warmer, wetter winters and hotter, drier summers for the Pacific Northwest in the first half of the 21st century (Mote et al., 2008, Mote et al. 2014, p. 489). This may result in a change in species composition or reduction in the acreage of existing low-elevation forests. The general predicted trend in North American forests is declining occupancy by conifers and displacement by hardwoods. Both the frequency and intensity of wildfires and insect outbreaks are expected to increase over the next century in the Pacific Northwest (Littell et al. 2010, p. 130). One of the largest projected effects on Pacific Northwest forests is likely to come from an increase in fire frequency, duration, and severity. Westerling et al. (2006, pp. 940-941) analyzed wildfires and found that since the mid-1980s, wildfire frequency in western forests has nearly quadrupled compared to the average of the period from 1970-1986. The total area burned is more than 6.5 times the previous level and the average length of the fire season during 1987-2003 was 78 days longer compared to 1978-1986 (Westerling et al. 2006, p. 941). The area burned annually by wildfires in the Pacific Northwest is expected to double or triple by the 2080s (Littell et al. 2010, p. 140). Wildfires are now the primary cause of spotted owl habitat loss on Federal lands, with about 505,800 acres of nesting/roosting habitat loss attributed to wildfires from 1993 to 2012 (Davis et al. 2016, table 7, p. 22).

In its review of the status of the northern spotted owl in California (CDFW 2016, p. 153-155), the California Department of Fish and Wildlife (CDFW) evaluated the possible effects of climate change upon northern spotted owl and the forested habitats on which it depends. In general, CDFW (2016, p. 153-155) determined that climate change is occurring within the northern spotted owl's entire range, including California, with many climate projections forecasting steady changes in the future. They reported that climate change studies predict future conditions that may negatively impact northern spotted owls, such as wet and cold springs, more frequent and severe summer heat waves, decreased fog along the coast, shifts in forest species composition, and increased frequency of severe wildfire events. However, CDFW (2016, p. 153-155) also reported that in some instances predicted future conditions, such as increased frequency of low to moderate severity fires and expansion of suitable owl habitat forest types, may be favorable to the northern spotted owl in the long-term. They further reported that in California, current rates of temperature and precipitation change predict hotter and drier conditions in some areas of the northern spotted owl's range, and wetter colder conditions in other areas of the range. They looked at past precipitation and temperature trends, and reported that drying trends across most of the northern spotted owl's range in California, coupled with warmer winters and cooler summers in the interior and cooler winters and warmer summers

along the coast, may play a role in both owl and prey population dynamics. CDFW (2016, p. 153-155) recommended that further research is necessary to understand how climate change may be affecting northern spotted owls in California and throughout its range.

Potential changes in temperature and precipitation have important implications for spotted owl reproduction and survival. Wet, cold weather during the winter or nesting season, particularly the early nesting season, has been shown to negatively affect spotted owl reproduction (Olson et al. 2004, p. 1039, Dugger et al. 2005, p. 863), survival (Franklin et al. 2000 pp. 576-577, Olson et al. 2004, p. 1039, Glenn et al. 2011, p. 1279), and recruitment (Glenn et al. 2010, pp.2446-2547). Cold, wet weather may reduce reproduction and/or survival during the breeding season due to declines or decreased activity in small mammal populations so that less food is available during reproduction when metabolic demands are high (Glenn et al. 2011, pp. 1288-1289). Cold, wet nesting seasons may increase the mortality of nestlings due to chilling and reduce the number of young fledged per pair per year (Franklin et al. 2000, p.557, Glenn et al. 2011, p. 1286). Most recently, the relationships between spotted owl populations and climate was complex and variable, but rangewide, Dugger and others (2016, page 98) suggested that survival increased when winters were warmer and drier. This may become a factor in population numbers in the future; given climate change predictions for the Pacific Northwest include warmer, wetter winters.

Drought or hot temperatures during the summer have also been linked to reduced spotted owl recruitment (Glenn et al. 2010, p. 2549). Drier, warmer summers and drought conditions during the growing season strongly influence primary production in forests, food availability, and the population sizes of small mammals that spotted owls prey upon (Glenn et al. 2010, p. 2549).

Various types of changes in climate can have direct or indirect effects on species. These effects may be positive, neutral, or negative and they may change over time, depending on the species and other relevant considerations, such as the effects of interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007, pp. 8–14, 18–19). For the more central portion of the northern spotted owl's range such as the location of the action area, climate models have provided a series of projections. For example, annual temperatures are likely to increase up to 3 degrees in the next couple of decades. Total precipitation may remain roughly similar to historic levels but likely increasing in the fall and winter months. Rising temperatures will cause snow to turn to rain in the lower elevations. As a result, the area is likely to experience more severe storm events, variable weather, higher and flashier winter and spring runoff events and increased flooding. Reduced snowpack and soil moisture along with hotter temperatures and longer fire seasons likely will increase significantly (Doppelt et al. 2008).

While a change in forest composition or extent is likely as a result of climate change, the rate of that change is uncertain. In forests with long-lived dominant tree species, mature individuals can survive these stresses, so direct effects of climate on forest composition and structure would most likely occur over a longer time scale (100 to 500 years) in some areas than disturbances such as wildfire or insect outbreaks (25 to 100 years) (McKenzie et al. 2009). The presence of high-quality habitat may buffer the negative effects of cold, wet, springs and winters on survival of spotted owls as well as ameliorate the effects of heat. This habitat might help maintain a stable prey base, thereby reducing the cost of foraging during the breeding season when

energetic needs are high (Franklin et al. 2000).

Although the scientific literature has explored the link between climate change and the invasion by barred owls, changing climate alone is unlikely to have caused the invasion (Livezey 2009). In general, climate change can increase the success of introduced or invasive species in colonizing new territory. Invasive animal species are more likely to be generalists, such as the barred owl, than specialist, such as the spotted owl and adapt more successfully to a new climate than natives.

In summary, effects of climate change may vary across the range, but is likely to exacerbate some existing threats to the spotted owl such as the projected potential for increased habitat loss from drought-related fire, tree mortality, insects and disease, as well as affecting reproduction and survival during years of extreme weather.

*Exposure to Toxicants*

Toxicants were not identified as a threat when the northern spotted owl was listed, but a growing body of information suggests exposure to anti-coagulant rodenticides, fertilizers, other contaminants, as well as other factors associated with marijuana cultivation represent a growing concern for northern spotted owls. Recent accounts show that the scope and scale of exposure from illegal cultivation is increasing on federal and non-federal ownerships; these threats extend northern spotted owls and many other wildlife species and the resources they depend upon (Thompson et al. 2013, entire, Gabriel et al. 2013, entire; Wengert et al. 2015, p. 8; CDFW 2016 pp. 176-177, CEPA 2017b, p.1; Gabriel et al. 2018, entire; Higley et al. 2017 (abstracts). Known grow sites have been found to intersect with both subspecies of spotted owl ranges throughout California. On Forest Service lands in 2014, more than 620,000 marijuana plants on about 1,500 ac (607 ha) were removed from 167 different sites; about 90 percent of which were in California (US Senate press release 2015). Over 600 trespass grow sites were reported on mixed California ownerships in 2010 (Wengert et al. 2015, p. 8). Increases in mortalities from and exposure to pesticides in fishers in the Sierras and Northern California indicate that toxicants from marijuana cultivation suggest increasing trends (Gabriel et al. 2015, pp. 5-8, 14).

Illegal cultivation is a serious issue in the Klamath Physiographic Province, an area recognized as an important area for northern spotted owl populations (Schumaker et al. 2014). In Southwestern Oregon in Jackson and Josephine Counties alone, a multi-agency Drug Task force reported a total of 100 illegal marijuana cultivation sites containing approximately 294,090 plants between 2005-2014 (Caruthers, R. pers. comm. 2017). Many of these sites were located within known spotted owl home ranges, cores, or nest stands (Clayton, D. pers. comm. 2017).

Known exposure and recent data on impacts to barred owls suggest serious implications for northern spotted owls. In Hoopa Tribal lands in northwestern California, of 176 barred owls tested for exposure to anticoagulant rodenticides, 65 percent tested positive for one or more second generation ARs; many of these were collected from known spotted owl home ranges (Higley et al. 2017). From another data set in northwestern California, barred owls collected from 37 historical northern spotted owl territories have been tested for ARs (Gabriel et al. 2018, p. 4). In Oregon, 40 percent of barred owls sampled (n=10) tested positive for rodenticides.

*Disturbance*
Northern spotted owls may also respond physiologically to a disturbance without exhibiting a significant behavioral response. In response to environmental stressors, vertebrates secrete stress hormones called corticosteroids (Campbell 1990, p. 925). Although these hormones are essential for survival, extended periods with elevated stress hormone levels may have negative effects on reproductive function, disease resistance, or physical condition (Carsia and Harvey 2000, pp. 517-518; Saplosky et al. 2000, p. 1). In avian species, the secretion of corticosterone is the primary non-specific stress response (Carsia and Harvey 2000, p. 517). The quantity of this hormone in feces can be used as a measure of physiological stress (Wasser et al. 1997, p. 1019). Recent studies of fecal corticosterone levels of northern spotted owls indicate that low intensity noise of short duration and minimal repetition does not elicit a physiological stress response (Tempel and Gutiérrez 2003, p. 698; Tempel and Gutiérrez 2004, p. 538). However, prolonged activities, such as those associated with timber harvest, may increase fecal corticosterone levels depending on their proximity to northern spotted owl core areas (Wasser et al. 1997, p.1021; Tempel and Gutiérrez 2004, p. 544).

The effects of noise on spotted owls are largely unknown, and whether noise is a concern has been a controversial issue. The effect of noise on birds is extremely difficult to determine due to the inability of most studies to quantify one or more of the following variables: 1) timing of the disturbance in relation to nesting chronology; 2) type, frequency, and proximity of human disturbance; 3) clutch size; 4) health of individual birds; 5) food supply; and 6) outcome of previous interactions between birds and humans (Knight and Skagan 1988, pp. 355-358). Additional factors that confound the issue of disturbance include the individual bird's tolerance level, ambient sound levels, physical parameters of sound, and how it reacts with topographic characteristics and vegetation, and differences in how species perceive noise.

Information specific to behavioral responses of spotted owls to disturbance is limited, research indicates that recreational activity can cause Mexican spotted owls (*S. o. lucida*) to vacate otherwise suitable habitat (Swarthout and Steidl 2001, p. 314) and helicopter overflights can reduce prey delivery rates to nests (Delaney et al. 1999, p. 70). Additional effects from disturbance, including altered foraging behavior and decreases in nest attendance and reproductive success, have been reported for other raptors (White and Thurow 1985, p. 14; Andersen et al. 1989, p. 296; McGarigal et al. 1991, p. 5).

Although it has not been conclusively demonstrated, it is anticipated that nesting spotted owls may be disturbed by heat and smoke as a result of burning activities during the breeding season.

**Conservation Needs of the Spotted Owl**

Based on the above assessment of threats, the spotted owl has the following habitat-specific and habitat-independent conservation (i.e., survival and recovery) needs:

*Habitat-specific Needs*
1. Large blocks of habitat capable of supporting clusters or local population centers of spotted owls (e.g., 15 to 20 breeding pairs) throughout the owl's range;
2. Suitable habitat conditions and spacing between local spotted owl populations throughout

its range that facilitate survival and movement;
3. Suitable habitat distributed across a variety of ecological conditions within the northern spotted owl's range to reduce risk of local or widespread extirpation;
4. A coordinated, adaptive management effort to reduce the loss of habitat due to catastrophic wildfire throughout the spotted owl's range, and a monitoring program to clarify whether these risk reduction methods are effective and to determine how owls use habitat treated to reduce fuels; and
5. In areas of significant population decline, sustain the full range of survival and recovery options for this species in light of significant uncertainty.

*Habitat-independent Needs*
1. A coordinated research and adaptive management effort to better understand and manage competitive interactions between spotted and barred owls; and
2. Monitoring to understand better the risk that WNV and sudden oak death pose to spotted owls and, for WNV, research into methods that may reduce the likelihood or severity of outbreaks in spotted owl populations.

**Conservation Strategy to Address Habitat Loss and Fragmentation**

Since 1990, various efforts have addressed the conservation needs of the spotted owl and attempted to formulate conservation strategies based upon these needs. These efforts began with the ISC's Conservation Strategy (Thomas et al. 1990); they continued with the designation of critical habitat (USDI FWS 1992b), the Draft Recovery Plan (USDI FWS 1992a), and the Scientific Analysis Team report (Thomas et al. 1993), report of the Forest Ecosystem Management Assessment Team (Thomas and Raphael 1993); and they culminated with the NWFP (USDA FS/USDI BLM 1994a). Recently, the management strategy for portions of Bureau of Land Management lands in Oregon (2.5 million acres) was modified and is no longer following all measures described in the NWFP (USDI BLM 2016a, entire and USDI BLM 2016b, entire). In comparison to the NWFP land use allocations, the Late-Successional Reserve (LSR) designs of the revised Resource Management Plans (RMPs) make similar contributions to the development and spacing of the large habitat blocks needed for northern spotted owl conservation. The RMPs includes approximately 177,000 more acres (71,629 ha) of LSR and Riparian Reserves than in the NWFP. These land use allocations represent 36 and 27 percent of the RMP lands, respectively, and will be managed for the retention and development of large trees and complex forests across the RMP landscape (USDI FWS 2016, Table 1, p. 9). Two additional key provisions differ from previous strategies, including a mitigation that the BLM would participate in, cooperate with, and provide support for an interagency program for barred owl management to implement Recovery Action 30 when the Service determines the best manner in which barred owl management can contribute to the recovery of the northern spotted owl. Also, timber sales that would cause the incidental take of northern spotted owls from timber harvest would not be authorized until implementation of a barred owl management program has begun (USDI BLM 2016a, p 19 and USDI BLM 2016b, p. 19). Overall fundamentals of these large-scale conservation strategies have been based upon the reserve design principles first articulated in the ISC's report, which are summarized as follows:

- Species that are well distributed across their range are less prone to extinction than

species confined to small portions of their range.
- Large blocks of habitat, containing multiple pairs of the species, are superior to small blocks of habitat with only one to a few pairs.
- Blocks of habitat that are close together are better than blocks far apart.
- Habitat that occurs in contiguous blocks is better than habitat that is more fragmented.
- Habitat between blocks is more effective as dispersal habitat if it resembles suitable habitat.

*Federal Contribution to Recovery*
Since it was signed on April 13, 1994, the NWFP has guided the management of Federal forest lands within the range of the spotted owl (USDA FS/USDI BLM 1994a, 1994b). The NWFP was designed to protect large blocks of old growth forest and provide habitat for species that depend on those forests including the spotted owl, as well as to produce a predictable and sustainable level of timber sales. The NWFP included land use allocations which would provide for population clusters of northern spotted owls (i.e., demographic support) and maintain connectivity between population clusters. Certain land use allocations in the plan contribute to supporting population clusters: LSRs, Managed Late-successional Areas, and Congressionally Reserved areas. Riparian Reserves, Adaptive Management Areas, and Administratively Withdrawn areas can provide both demographic support and connectivity/dispersal between the larger blocks, but were not necessarily designed for that purpose. Matrix areas were to support timber production while also retaining biological legacy components important to old-growth obligate species (in 100-acre owl cores, 15 percent late-successional provision, etc. (USDA FS/USDI BLM 1994a, USDI FWS 1994) which would persist into future managed timber stands.

The NWFP with its rangewide system of LSRs was based on work completed by three previous studies (Thomas et. al. 2006): the 1990 Interagency Scientific Committee (ISC) Report (Thomas et. al. 1990), the 1991 report for the Conservation of Late-successional Forests and Aquatic Ecosystems (Johnson et. al. 1991), and the 1993 report of the Scientific Assessment Team (Thomas et. al. 1993).

The Forest Ecosystem Management Assessment Team and the NWFP predicted, based on expert opinion, the spotted owl population would decline in the Matrix land use allocation over time, while the population would stabilize and eventually increase within LSRs as habitat conditions improved over the next 50 to 100 years (Thomas and Raphael 1993, p. II-31; USDA FS/USDI BLM 1994a, 1994b, p. 3&4-229). The results of the first decade of monitoring, Lint (2005, p. 18) did not yield conclusions whether implementation of the NWFP would reverse the spotted owl's declining population trend because not enough time had passed to provide the necessary measure of certainty. However, the results from the first decade of monitoring did not provide any reason to depart from the objective of habitat maintenance and restoration as described in the NWFP (Lint 2005, p. 18; Noon and Blakesley 2006, p. 288). Other stressors that occur in suitable habitat, such as the range expansion of the barred owl (already in action) and infection with WNV (which may or may not occur) may complicate the conservation of the spotted owl. Recent reports about the status of the spotted owl offer few management recommendations to deal with these emerging threats.

On June 28, 2011, the Service published the Revised Recovery Plan for the Northern Spotted Owl (USDI FWS 2011b). The recovery plan identifies threats from competition with barred owls, ongoing loss of northern spotted owl habitat as a result of timber harvest, loss or modification of northern spotted owl habitat from uncharacteristic wildfire, and loss of amount and distribution of northern spotted owl habitat as a result of past activities and disturbances (USDI FWS 2011b, p. II-2 and Appendix A). To address these threats, the current recovery strategy identifies five main steps: 1) development of a rangewide habitat modeling framework; 2) barred owl management; 3) monitoring and research; 4) adaptive management; and 5) habitat conservation and active forest restoration (USDI FWS 2011b, p. II-2). The recovery plan lists recovery actions that address each of these items, some of which were retained from the 2008 recovery plan (USDI FWS 2008). The Managed Owl Conservation Areas and Conservation Support Areas recommended in the 2008 recovery plan are not a part of the recovery strategy outlined in the Revised Recovery Plan. The Service completed a rangewide, multi-step habitat modeling process to help evaluate and inform management decisions and critical habitat development (USDI FWS 2011b, Appendix C).

The Revised Recovery Plan recommended implementing a robust monitoring and research program for the spotted owl. The recovery plan encourages these efforts by laying out the following primary elements to evaluate progress toward meeting recovery criteria: monitoring spotted owl population trends, comprehensive barred owl research and monitoring, continued habitat monitoring; inventory of spotted owl distribution, and; explicit consideration for climate change mitigation goals consistent with recovery actions (USDI FWS 2011b, p. II-5). The Revised Recovery Plan also strongly encourages land managers to be aggressive in the implementation of recovery actions, including strategies that include active forest management. In other words, land managers should not be so conservative that, to avoid risk, they forego actions that are necessary to conserve the forest ecosystems that are necessary to the long-term conservation of the spotted owl. But they should also not be so aggressive that they subject spotted owls and their habitat to treatments where the long-term benefits do not clearly outweigh the short-term risks. Finding the appropriate balance to this dichotomy will remain an ongoing challenge for all who are engaged in spotted owl conservation (USDI FWS 2011b, p. II-12). The Revised Recovery Plan estimates that recovery of the spotted owl could be achieved in approximately 30 years (USDI FWS 2011b, p. II-3). The Revised Recovery Plan and the critical habitat designation build on the NWFP and recommends continued implementation of the NWFP and its standards and guides (USDI FWS 2011b, p. I-1).

Spotted Owl Recovery Units

The 2011 Final Revised Recovery Plan for the Northern Spotted Owl determined that the 12 existing physiographic provinces meet the criteria for use as recovery units (USDI FWS 2011b, p. III 1-2). Recovery criteria, as described in the 2011 Final Revised Recovery Plan (p. 11-3), are measurable and achievable goals that are believed to result through implementation of the recovery actions described in the recovery plan. Achievement of the recovery criteria will take time and are intended to be measured over the life of the plan, not on a short-term basis. The criteria are the same for all 12 identified recovery units. The four recovery criterion are: 1) stable population trend, 2) adequate population distribution, 3) continued maintenance and recruitment of northern spotted owl habitat, and 4) post-delisting monitoring (USDI FWS 2011b, p III-3).

The 2011 Revised Recovery Plan for the Northern Spotted Owl (USDI FWS 2011b) contains 14 recovery actions that specifically address northern spotted owl habitat loss and degradation. Two actions of primary importance are recovery actions 10 and 32:

- Recovery Action 10: Conserve northern spotted owl sites and high value northern spotted owl habitat to provide additional demographic support to the northern spotted owl population. This action addresses both nesting/roosting and foraging habitat.
- Recovery Action 32: Because northern spotted owl recovery requires well distributed, older and more structurally complex multi-layered conifer forests on Federal and non-Federal lands across its range, land managers should work with the Service…to maintain and restore such habitat while allowing for other threats, such as fire and insects, to be addressed by restoration management actions. These high-quality northern spotted owl habitat stands are characterized as having large diameter trees, high amounts of canopy cover, and decadence components such as broken-topped live trees, mistletoe, cavities, large snags, and fallen trees. This action addresses nesting/roosting habitat.

Recovery actions 10 and 32 are implemented on reserved areas by the USFS and BLM through the NWFP and the Resource Management Plans (RMPs); these two regulatory actions are discussed in more detail in Section 6. The large reserve network created under the NWFP and RMPs facilitates implementation of recovery actions 10 and 32 by protection of current nesting/roosting and foraging habitat, protection of spotted owl nest sites, and allowing for recruitment of new northern spotted owl habitat. Through the section 7 consultation process, the Service reviews the management activities implemented under the NWFP and RMPs and provides technical assistance to the USFS and BLM in making activities within or outside of reserves consistent with recovery actions 10 and 32 to the extent consistent with other land management priorities. Nesting/roosting and foraging habitat associated with both recovery actions 10 and 32 may decrease in local areas, but over the larger area and time, habitat that is associated with these recovery actions is increasing and will continue to increase under both the NWFP and RMPs.

*Conservation Efforts on Non-Federal Lands*

Non-Federal lands contributed 3,149,700 ac (1,274,638 ha) to the total 12,103,700 ac (4,898,193 ha) of nesting/roosting habitat available for breeding northern spotted owls in 2012 (Davis et al. 2016, pp. 21-22). There are portions of the range where habitat on Federal lands is lacking or of low quality, or where there is little Federal ownership; State and private lands may be important to provide demographic support (pair or cluster protection) and habitat connectivity for northern spotted owl in key areas such as southwestern Washington, northwestern Oregon (potentially including parts of the Tillamook and Clatsop State Forests), and northeastern California (USDI FWS 2011b, p. III-51). Timber harvest on State and private lands in Washington, Oregon, and California is regulated by each State's forest practice rules. The level of northern spotted owl conservation included in each State's regulations varies. Furthermore, while recovery efforts for the northern spotted owl are primarily focused on Federal land, Recovery actions 14 in the 2011 Revised Recovery Plan centered on seeking partnership with non-Federal landowners to supplement Federal conservation efforts, including voluntary actions like Habitat Conservation Plans (HCPs) and Safe Harbor Agreements (SHAs). There are a total of 21 current conservation plans in these states, including 7 HCPs and 3 SHAs located in Washington, 2 HCPs and 5 SHAs

in Oregon, and 2 HCPs and one SHA in California, with an additional SHA occurring in both Washington and Oregon.

*U.S. Fish and Wildlife Habitat Conservation Plans and Safe Harbor Agreements*

The purpose of the HCP and SHA process is to provide for the conservation of endangered and threatened species while at the same time authorizing the incidental take of those species. HCPs are required as part of an application for an incidental take permit. They describe the anticipated effects of the proposed taking; how those impacts will be minimized, and mitigated; and how the HCP is to be funded among other things. The Secretary must issue the permit if statutory issuance criteria are met, including that the applicant will minimize and mitigate the effects of the taking to the maximum extent practicable, the taking will not jeopardize the continued existence of the species, and funding to implement the plan is assured. 16 U.S.C. 1539(a)(2)(B). In developing HCPs, people applying for incidental take permits describe measures designed to minimize and mitigate the effects of their actions and receive formal assurances from the Service that if they fulfill the conditions of the HCP, the Service will not require any additional or different management activities by the participants without their consent. SHAs are voluntary agreements between non-Federal property owners and the Service; in exchange for actions that contribute to the recovery of listed species on non-Federal lands, participating property owners may return the enrolled property to the baseline conditions that existed at the beginning of the SHA. Incidental Take Permits that result from both HCPs and SHAs are intended to allow non-Federal entities to undertake actions that incidentally "take" species protected under the Act.

HCPs are not required to have a net benefit and SHAs are designed to have a temporary net gain for northern spotted owls. Under these plans, timber harvest has continued, resulting in the loss of nesting/roosting, foraging, and dispersal habitat; we do not currently have an analysis of habitat loss on lands without conservation plans compared to habitat loss on lands covered by HCPs and SHAs. Although the HCPs do not provide a net conservation benefit to northern spotted owl, they provide mitigation for habitat loss or slow down habitat loss through the required conservation measures. SHAs do provide a net conservation benefit to the northern spotted owl, and both conservation plans eliminate uncertainty with respect to landowners' actions in northern spotted owl habitat, and provide the Service an opportunity to provide technical assistance to landowners in the development of conservation measures included in the agreements. Therefore, in this context, both HCPs and SHAs have contributed to the overall conservation of spotted owls.

In Washington, there are seven northern spotted owl-related HCPs currently in effect covering 2 million ac (80,9371 ha) of non-Federal lands, one of which covers Washington Department of Natural Resources (DNR) lands. These HCPs still allow timber harvest but are designed to retain some nesting habitat and or connectivity over the next few decades. There are four northern spotted owl-related SHAs in Washington, with one including some lands in Oregon. The primary intent of SHAs is to maintain or create potential northern spotted owl habitat. In addition, there is a long term habitat management agreement covering 13,000 ac (5,261 ha) in which authorization of take was provided through an incidental take statement (section 7) associated with a Federal land exchange (USDI FWS 2011b, p. A-15). While timber harvest and habitat loss continues on lands covered by these agreements, the plans retain some

nesting/roosting habitat throughout the area or in strategic locations, and provide habitat connectivity. Overall, HCPs, and SHAs in Washington provide some protection to northern spotted owls and their habitat. However, nesting/roosting and foraging habitat continue to decline due to timber harvest on non-Federal lands in Washington.

In Oregon, there are two northern spotted owl-related HCPs currently in effect covering 210,400 ac (85,146 ha) of non-Federal lands. These HCPs still allow timber harvest but are designed to retain some nesting habitat and or connectivity over the next few decades. There are two northern spotted owl-related SHAs occurring in Oregon. One SHA is a Washington SHA that covered some Oregon lands. The other SHA is a programmatic SHA with the Oregon Department of Forestry with 13 landowners with 3,484 acres enrolled. The primary intent of SHAs is to maintain or create potential northern spotted owl habitat. Strategies employed in the programmatic Oregon Department of Forestry SHA include, maintaining existing suitable habitat, increase time between harvests to allow for habitat development, and to lightly to moderately thin younger forestry stands that are currently not habitat (to increase tree diameter and stand diversity) (USDI FWS 2011b, p. A-16). There are 4 additional SHAs in Oregon related to the Barred Owl Removal Experiment explained below in the barred owl section. While timber harvest and habitat loss continue on lands covered by these HCPs and SHAs in Oregon, the plans retain some nesting/roosting habitat throughout the area or in strategic locations, and provide habitat connectivity. Overall, HCPs, and SHAs in Oregon provide some protection to northern spotted owls and their habitat. However, nesting/roosting and foraging habitat continue to decline due to timber harvest on non-Federal lands in Oregon.

In California, there are two northern spotted owl-related HCPs currently in effect covering 211,765 ac (85,698ha) of non-Federal lands. These HCPs still allow timber harvest but are designed to retain some nesting habitat and or connectivity over the next few decades. There is one northern spotted owl-related SHA in California. The primary intent of SHAs is to maintain or create potential northern spotted owl habitat. While timber harvest and habitat loss continues on lands covered by these agreements, the plans retain some nesting/roosting habitat throughout the area or in strategic locations, and provide habitat connectivity. Overall, HCPs, and SHAs in California provide some protection to northern spotted owls and their habitat. However, nesting/roosting and foraging habitat continue to decline due to timber harvest on non-Federal lands in California.

*State Forest Practice Rules*

The majority of northern spotted owl conservation is expected from Federal lands, but the Service's primary expectations for private lands are for their contributions to demographic support (pair or cluster protection) to Federal lands, or their connectivity with Federal lands. Timber harvest on State and private lands in Washington, Oregon, and California is regulated by each State's forest practice rules. The level of northern spotted owl conservation included in each State's regulations varies Each State's rules are described below.

*Washington*

The northern spotted owl was listed as endangered species in Washington State by the

Washington Fish and Wildlife Commission in 1988 to prioritize conservation for the subspecies (WDFW 2017). Timber harvest on State and private lands in Washington is guided by a number of State laws and policies, except for Washington Department of Natural Resources (WDNR) lands that are covered by an HCP. The Washington State Environmental Policy Act (SEPA) requires analysis of environmental impacts and consideration of reasonable alternatives for actions proposed by the State. State timber harvest activities must also comply with the State Forest Practices Act (Chapter 76.09 RCW), which regulates all forest management activities in Washington. The management of State trust lands, specifically, is guided by the Forest Resource Plan, which was adopted by the Board of Natural Resources in 1992. Among other things, the policies of the Plan require the Washington DNR analyze and potentially modify the impacts of its activities on watersheds, wildlife habitat, special ecological features, wetlands, and other natural resources to maintain healthy forests for future generations.

In 1996, the State Forest Practices Board adopted rules (Washington Forest Practices Board 1996) that would contribute to conserving the northern spotted owl and its habitats on non-Federal lands. Adoption of the rules was based in part on recommendations from a Science Advisory Group that identified important non-Federal lands and recommended roles for those lands in northern spotted owl conservation (Hanson et al. 1993, pp. 11-15; Buchanan et al. 1994, p. ii). The 1996 rule package was developed by a stakeholder policy group and then reviewed and approved by the Forest Practices Board (Buchanan and Swedeen 2005, p. 9). The 1996 rules identified 10 landscapes, or Spotted Owl Special Emphasis Areas (SOSEAs) where owl protections on non-Federal lands would be emphasized. Protections provided under the State Environmental Policy Act for those portions of owl sites located beyond the boundaries of the SOSEAs were largely eliminated (Buchanan and Swedeen 2005, p. 7). The overarching policy goal of the Washington Forest Practices Rules is to complement the conservation strategy on Federal lands, and as such the SOSEAs are adjacent to Federal lands. The SOSEAs are designed to provide a larger landscape for demographic and dispersal support for northern spotted owls with the long-term goal of supporting a viable population of northern spotted owls in Washington.

The Forest Practices Rules for northern spotted owls can be described as containing three basic types of provisions: 1) regulations that apply outside SOSEAs, 2) a circle-based protection scheme for northern spotted owl sites inside SOSEAs (retain all suitable habitat within 0.7 mi (1 km) of site center and retain 40 percent of suitable habitat within 1.8 to 2.7 mi (2.9 to 4.3 km) radius of home range), and 3) landscape-level planning options for inside SOSEAs. To avoid disturbance of nesting northern spotted owls inside SOSEAs, the rules also include timing restrictions from March 1 to August 31 within 0.25 miles of a site center for several potentially disruptive activities (e.g., road construction). Forest practices rules outside the SOSEAs are designed to protect the immediate vicinity of northern spotted owl site centers during the nesting season (March 1 to August 31) by restricting harvest within the best 70 ac (28 ha) of habitat around the site center and requiring additional environmental analysis for permitting (of harvesting, road construction, or aerial application of pesticides), but outside the nesting season there are no owl-related protections outside SOSEAs that constrain harvest of suitable northern spotted owl habitat in spotted owl management circles (Buchanan and Swedeen 2005, p. 14).

Within SOSEAs, the rules were intended to maintain the viability of each northern spotted owl

site center by establishing that enough suitable habitat should be maintained to protect the viability of owls associated with each northern spotted owl site center, or to provide for the goals established in Spotted Owl Special Emphasis Areas. Due to extensive timber harvest activities in the decades leading up to listing of the northern spotted owl, most northern spotted owl management circles centered on non-Federal lands have far less habitat than the viability threshold identified (see below) when the rule went into effect. Because the rules do not include provisions for restoration of habitat to achieve the viability threshold at northern spotted owl sites these circles remain far below those thresholds. For individual site centers, the habitat considered necessary to maintain viability is as follows: (a) all suitable northern spotted owl habitat within 0.7 mi (1.1 km) of each northern spotted owl site center; (b) at least 5,863 ac (2,373 ha) of suitable northern spotted owl habitat within of 2.7 mi (4.3 km) of a site center in the Hoh-Clearwater Spotted Owl Special Emphasis Area on the western Olympic Peninsula, and (c) at least 2,605 ac (1,054 ha) of suitable northern spotted owl habitat within 1.8 mi (2.9 km) of a site center in all other Spotted Owl Special Emphasis Areas. At all sites within SOSEAs, any proposed harvest of suitable northern spotted owl habitat within a territorial owl circle (status 1, 2, or 3 in the Washington Department of Fish and Wildlife database) would be considered a "Class-IV special" and would trigger State Environmental Policy Act review; such activities would require a Class IV special forest practices permit and an environmental impact statement per the State Environmental Policy Act (Buchanan and Swedeen 2005, p. 15-16).

The Forest Practices Board in Washington has a long-standing relationship with the Service and collaborates extensively on owl conservation. The Service provided extensive technical assistance in the development of the Board's existing owl rules. The Board was recognized in the Revised Recovery Plan for the Northern Spotted Owl (USDI FWS 2011b) for its ongoing owl conservation efforts in Recovery Action 18 encouraged to continue to use its existing processes "to identify areas on non-Federal lands in Washington that can make strategic contributions to northern spotted owl conservation over time. The Service encourages timely completion of the Board's efforts and will be available to assist as necessary." The Board convened the Northern Spotted Owl Implementation Team (NSOIT) in 2010 to develop incentives for landowners to achieve conservation goals for northern spotted owls and to identify the temporal and spatial allocation of conservation efforts on non-Federal lands; a draft product is due to be completed in 2017. The NSOIT conducted a pilot project testing different thinning prescriptions in northern spotted owl habitat but the project has since been discontinued. These efforts underway have evolved over years of collaboration and are designed to change the dynamic away from fear and resistance to partnership and participation. The Service has and is providing funding to support the work of the NSOIT. Overall, State forest practice rules in Washington provide some protection to northern spotted owls and their habitat. However, nesting/roosting and foraging habitat continue to decline due to timber harvest on non-Federal lands in Washington.

*Oregon*

The northern spotted owl is listed as a threatened species in Oregon (ODFW 2017). The Oregon Fish and Wildlife Commission's long-term goal for species listed as threatened or endangered under the Oregon Endangered Species Act is to manage the species and their habitats so that the status of the species improves to a point where listing is no longer necessary. Timber harvest on

non-Federal lands in Oregon is guided by the Forest Practices Act and Forest Practices Rules (ODF 2014). The Oregon Forest Practices Act restricts timber harvest within 70 ac (28 ha) core areas around sites occupied by an adult pair of northern spotted owls capable of breeding (as determined by recent protocol surveys), but it does not provide for protection of northern spotted owl habitat beyond these areas (ODF 2014, pp. 61-62). In general, no large-scale northern spotted owl habitat protection strategy or mechanism currently exists for non-Federal lands in Oregon.

State forests in particular are managed to achieve “greatest permanent value,” considering economics, environmental, and cultural goals. Each State Forest has a Forest Management Plan that seeks to implement these ideals. Ultimately, the State’s goal is to produce timber revenue and also provide for a range of habitats across ownerships. Specific policies and procedures have been adopted on State lands to protect and conserve the northern spotted owl and its habitat. The State Forests Division has an extensive survey program across all districts as part of annual harvest planning (approximately $1.4 million spent in 2016) and conducts density surveys on two districts. Division policy directs districts to avoid any harvest activity on State lands which results in less than 40% suitable habitat within the provincial home range of an owl or pair (a 1.2 – 1.5-mi (1.9- 2.4 km) radius circle centered on a nest site or activity center). Division policy also directs districts to avoid any harvest activity which results in less than 500 ac (202 ha) of suitable habitat within a 0.7-mi (1.1 km) radius (1000 ac (405 ha)) of a nest site or activity center. In addition, 30 percent of Oregon State forests must be managed for the development of “complex forest structure” and late-seral tree species, which could provide some level of conservation benefit for a number of wildlife species of concern, including the northern spotted owl (IEc 2012). Thirty percent of Oregon State forests must be managed for “complex forest structures” and late seral tree species, for the benefit of a number of wildlife species. The locations of these managed lands are based in part on locations of northern spotted owl nest sites. Within these areas, a variety of treatments are employed to promote complex habitat and species diversity. Overall, State forest practice rules in Oregon provide some protection to northern spotted owls and their habitat. However, nesting/roosting and foraging habitat continue to decline due to timber harvest on non-Federal lands in Oregon.

*California*

The northern spotted owl was listed as an endangered species under the California Endangered Species Act (CESA) in early 2016 (CDFW 2017). The incidental take of state-listed species is prohibited under the California Code of Regulations (783-783.8 and the California Fish and Game Code 2080 (CDFW 2016), unless permitted by an HCP. Forest management and forest practices on private lands in California, including harvesting for forest products or converting land to another use are regulated by the State under Division 4 of the Public Resources Code, and in accordance with the California Forest Practice Rules (CFPR)(California Code of Regulations, (CCR) Title 14, Sections 895-1115; CFPR)(CFPR 2017). The CFPR require surveys for northern spotted owls in nesting/roosting and foraging habitat and restrict timber harvest within 0.7–1.3 mi (1-2 km) of a northern spotted owl activity center. Under this framework, the California Department of Forestry and Fire Protection (CALFIRE) is the designated authority on forest management and forest practices on private lands in California.

All private land timber harvesting in California must be conducted in accordance with a site-specific Timber Harvest Plan (THP, for industrial timberlands) or Nonindustrial Timber Management Plan (NTMP, for non-industrial private timberland owners) that is submitted by the owner and is subject to administrative approval by the CALFIRE. The THP/NTMP must be prepared by a State-registered professional forester, and must contain site-specific details on the quantity of timber involved, where and how it will be harvested, and the steps that will be taken to mitigate potential environmental damage. The THP/NTMP and CALFIRE's review process are recognized as the functional equivalent to the environmental review processes required under the California Environmental Quality Act of 1970 (CEQA). The CFPRs require surveys for northern spotted owls in suitable habitat and to provide protection around activity centers. Under the CFPRs, no THP or NTMP can be approved if it is likely to result in incidental take of federally-listed species, unless the take is authorized by a Federal incidental take permit.

For private timber lands in California not covered by a HCP or SHA, the policy of the State with regard to the northern spotted owl and timber harvest can be characterized as one of "take avoidance," for which the Service (Arcata and Yreka Fish and Wildlife Offices) has recommended measures to avoid take of northern spotted owls, primarily through recommendations for habitat retention, timing of timber operations and survey procedures for northern spotted owls (described briefly below). The Director of CALFIRE is not authorized to approve any proposed THP or NTMP that would result in take of a federally-listed species, including the northern spotted owl, unless that taking is authorized under a Federal Incidental Take Permit (review process is outlined in 14 CCR 919.9 and 919.10). This latter point creates an incentive for private landowners to enter into HCPs or SHAs, or to implement take avoidance measures recommended by the USFWS.

Prior to 2000, the California Department of Fish and Wildlife (then, California Department of Fish and Game; CDFW) reviewed THPs and NTMPs to ensure that take of northern spotted owls was not likely to occur. From about 2000 until 2010, the Service assumed this role and reviewed THPs and NTMPs (hundreds per year) for northern spotted owl "take avoidance." From 2010, the Service and CALFIRE shared duties for northern spotted owl take avoidance review of THPs and NTMPs. Beginning in 2014, the northern spotted owl was listed as a candidate species for potential listing under the California Endangered Species Act; consequently, in 2014, CDFW began reviewing a small number of THPs and NTMPs annually for northern spotted owl take avoidance. On August 25, 2016, the California Fish and Game Commission recommended that the northern spotted owl be added to the State list of threatened and endangered animals. Regarding timber harvest on private lands in California after 2016, the Service, CALFIRE and CDFW have not formally discussed how the agencies will share reviewing duties for northern spotted owl take avoidance associated with THPs and NTMPs, but recommended habitat retention standards (i.e., Attachments A and B) and survey recommendations remain in effect. California is currently engaged in discussions with the Service addressing northern spotted owl use of post-fire landscapes currently lacking in the California Forest Practice Rules.

For timber harvest activities that occur on non-Federal lands (excluding California State Parks and lands covered under a HCP) within CAL FIRE's Coast Forest District (generally, within the range of the coast redwood), the Service (Arcata Fish and Wildlife Office) provided to CAL FIRE and foresters a document titled, Northern Spotted Owl Take Avoidance Analysis and

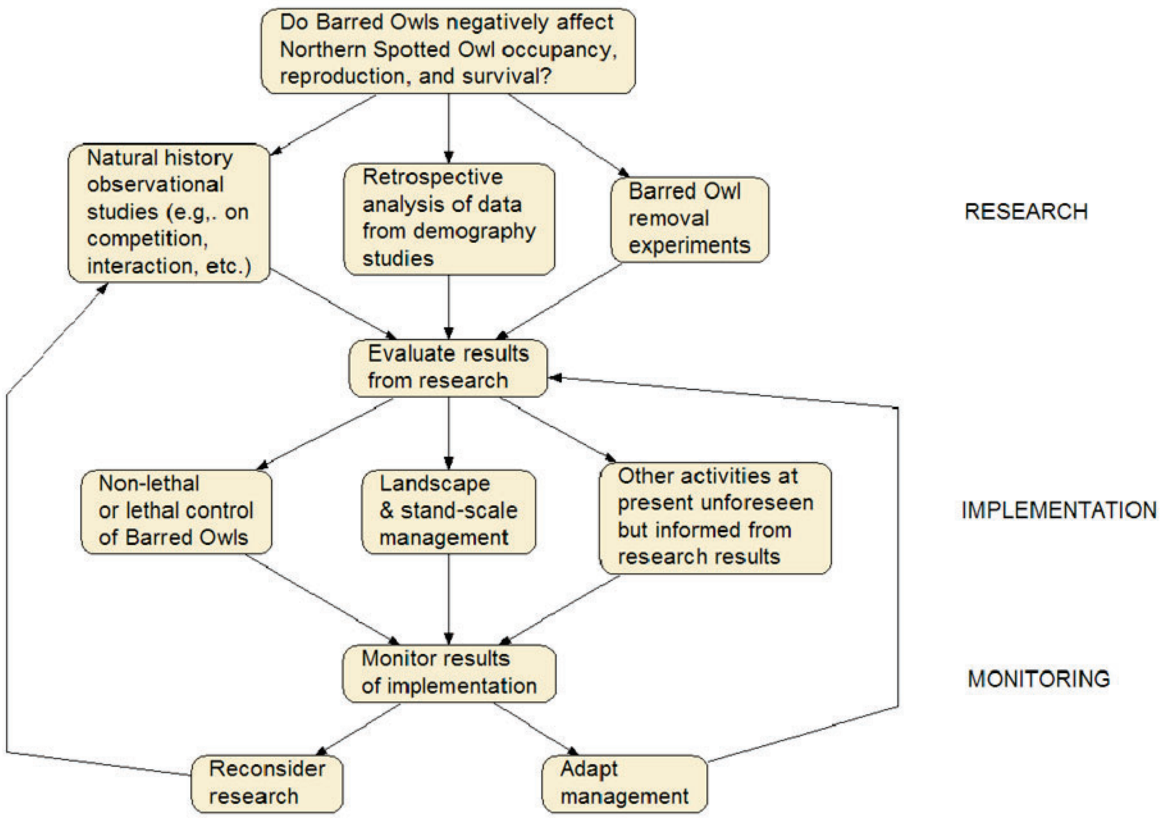
Guidance for California Coast Forest District ("Attachment A"), dated March 15, 2011. In general, recommended habitat retention guidelines around known active northern spotted owl activity centers in include: (1) delineation of a 100 ac (40 ha) "Core Area" comprised of "nesting/roosting" habitat (defined in Attachment A), in which timber harvest does not occur; (2) retention of at least an additional 100 ac (40 ha) of "nesting/roosting" habitat within 0.7 mi (1.1 km) of an activity center; and (3) retention of at least 300 ac (121 ha) of "foraging" habitat (defined in Attachment A) within 0.7 mi (1.1 km) of an activity center.

For timber harvest activities that occur on non-Federal lands within CAL FIRE's Interior Forest District, the Service (Arcata and Yreka Fish and Wildlife Offices) provided to CAL FIRE and foresters a document titled, Attachment B: Take Avoidance Analysis-Interior, dated February 27, 2008. In general, recommended habitat retention guidelines around known active northern spotted owl activity centers in include: (1) no harvest within 1,000 ft (305 m) of an activity center; (2) within 0.5 mi (0.8 km) radius (502 ac (203 ha) of an activity center, retention of four habitat types (as defined in Attachment B), including at least 100 ac (40 ha) "high quality nesting/roosting" habitat, 150 ac (61 ha) of "nesting/roosting" habitat, 100 ac (40 ha) of "foraging" habitat and 50 ac (20 ha) "low-quality foraging habitat"; and (3) between 0.5 mi (0.8 km) and 1.3 mi (2 km) radius circles on an activity center (2896 ac (1172 ha)), retention of greater than 935 ac (378 ha) of habitat, including at least 655 ac (265 ha) foraging habitat and at least 280 ac (113 ha) low-quality foraging habitat. Overall, State forest practice rules in California provide some protection to northern spotted owls and their habitat. However, nesting/roosting and foraging habitat continue to decline due to timber harvest on non-Federal lands in California.

**Conservation Measures to Address Barred Owls**

The 2011 Revised Recovery Plan for the Northern Spotted Owl contains ten recovery actions specific to addressing the barred owl threat. These include the establishment of protocols to detect barred owls and document barred owl site status and reproduction (Recovery Action 24), and the design and implementation of large-scale control experiments to assess effects of barred owl removal on spotted owl site occupancy, reproduction, and survival (Recovery Action 29). The manner in which this set of ten Recovery Actions is expected to contribute to northern spotted owl recovery is presented in Figure A-2.

**Figure A-2. Flowchart of barred owl Recovery Actions (USDI FWS 2011b, p. III-66, Figure III-1).**




Several barred owl recovery actions have been completed, and recovery Action 29 is currently ongoing. The Barred Owl Removal Experiment (USDI FWS 2013 and 78 FR 57171) was developed based on a pilot project at Green Diamond Resources study area that demonstrated barred owl removal had rapid, positive effects on northern spotted owl survival and the rate of population change (Dugger et al. (2016, p. 58). This experiment is currently being implemented under the direction of USGS, the Hoopa Tribe, and APHIS in partnership with the Service. The research program is evaluating the effectiveness of barred owl removal as a potential recovery strategy for northern spotted owls on one study area in Washington, two study areas in Oregon, and one study area in northern California. Barred owl removal was implemented on the California study area in fall/winter 2013-2014, and on the Washington and one of the Oregon study areas in fall/winter 2015-2016. Barred owl removal on the final Oregon study area was initiated in fall of 2016. Removal was scheduled to occur for a minimum of four consecutive years at each study area, but could be extended if spotted owl population results from the initial removal are not definitive.

Under the BLM RMPs, the BLM will support barred owl management on their lands as informed by the outcome of the Barred Owl Removal Experiment. In the interim, the BLM is avoiding

incidental take of northern spotted owls resulting from timber harvest on their lands. This support is intended to mitigate for the adverse effects associated with timber harvest and other resource programs, and result in a net positive impact on the recovery of northern spotted owls (USDI FWS 2016, p. 701).

Results from this experiment will provide future management guidance for the recovery of the northern spotted owl. Annual reports on study progress are provided each year, and a final report is anticipated in 2022. While results of the this experiment are not yet fully analyzed, removal has resulted in a substantial increase in the apparent survival of spotted owls on the Hoopa Reservation in California, the longest running of the study areas in the experiment, improving by nearly 10 percent over the apparent survival for the 5 years prior to the initiation of removal (Carlson et. al. 2019, p 9). On the three study areas in Oregon and Washington, the occupancy of spotted owl sites continues to decline on the control areas where no barred owls are removed, but appears to have stabilized or increased slightly on the treatment areas where barred owls are removed. However, the number of spotted owls on these areas is very low. Statistical analysis has not been completed on these areas yet (Wiens et. al. 2019, pp 12-13).

*Safe Harbor Agreements in Oregon for Barred Owl Experiment*

There are currently four SHAs specific to the Service's ongoing Barred Owl Removal Experiment in Oregon. The SHAs were limited to areas managed by landowners that were willing to work with the Service to provide access for survey and removal of barred owls on their lands within the study areas. Agreements were established with Roseburg Resources Company, Oxbow I LLC, Weyerhaeuser Company, and Oregon Department of Forestry to facilitate successful completion of this research project. The Barred Owl Removal Experiment implements Recovery Action 29 of the 2011 Revised Recovery Plan for the Northern Spotted Owl (USDI FWS 2011b, p. III-65). The Barred Owl Removal Experiment is being implemented on two study areas in Oregon, one in the Oregon Coast Ranges west of Eugene, Oregon, and one in the forest lands around Canyonville, Oregon. While the experiment is focused on Federal lands, the landscapes involved in the study areas include significant interspersed private and state lands. In the Oregon Coast Ranges study area, this includes lands owned by Roseburg Resources Company and Oxbow Timber I, LLC (SHA covers 9,400 ac (3,804 ha) of land total, 308 ac (125 ha) of currently unoccupied northern spotted owl habitat for which an incidental take permit was issued); Weyerhaeuser Company (SHA covers 1,072 ac (434 ha) total, 817 ac (331 ha) of currently unoccupied northern spotted owl habitat for which an incidental take permit was issued), and lands managed by Oregon Department of Forestry (SHA covers 20,000 ac (8,093 ha) total, 3,345 ac (1,354 ha) of currently unoccupied northern spotted owl habitat for which an incidental take permit was issued). In the Union/Myrtle (Klamath) study area in southern Oregon, this includes lands owned by Roseburg Resources Company (SHA covers 45,100 ac (18,251 ha) of land total, 7,080 ac (2865 ha) of currently unoccupied northern spotted owl habitat for which an incidental take permit was issued). Access on these non-Federal lands is important to the effective and efficient completion of the experiment.

Through these four SHAs, Roseburg Resources Company, Oxbow I LLC, Weyerhaeuser Company, and Oregon Department of Forestry will contribute to the conservation of the northern spotted owl by allowing the researchers to survey for barred owls on their lands throughout the

Study Area, and remove barred owls from their lands within the removal portion of the experiment. The section 10 permit issued to them as part of the SHA provides these landowners with short-term incidental take authorization through habitat modification for spotted owls that may return to non-baseline northern spotted owl sites (unoccupied by resident spotted owls for the three years prior to the initiation of removal on the area) after the removal of barred owls. However, this information and access is crucial to efficient and effective implementation of this experiment. Information from this experiment is critical to the development of a long-term management strategy to address the barred owl threat to the northern spotted owl.

**Rangewide Environmental Baseline**

The environmental baseline of the species incorporates the effects of all past human activities and natural events that led to the present-day status of the species and its habitat, including all previously consulted on effects (USDI FWS/USDC NMFS 1998, pp. 4-19).

*Habitat Trends*

The Service has used information provided by the USFS, BLM, and National Park Service to update the habitat baseline conditions by tracking relative habitat changes over time on Federal lands for northern spotted owls on several occasions, since the northern spotted owl was listed in 1990 (USDA FS/USDI BLM 1994b, USDI FWS 2001, Lint 2005, Davis et al. 2011, Davis et al. 2016). These NWFP monitoring reports assess the status and trends of spotted owl habitat across 22.1 million acres of federally administered forest lands in addition to 23.8 million acres of nonfederal forest lands within the range in the United States. The estimate of 7.4 million acres used for the NWFP in 1994 (USDA FS/USDI BLM 1994b) was believed to be representative of the general amount of northern spotted owl habitat on NWFP lands at that time. These periodic rangewide evaluations of northern spotted owl habitat (Lint 2005, Davis et al. 2011, Davis et al. 2016) are used to determine if the rate of potential change to northern spotted owl habitat has been consistent with changes in amount of habitat anticipated under the NWFP and described in the Final Supplemental Environmental Impact Statement (FSEIS; USFS and USDI 1994b). Each analysis has used more up-to-date and higher quality data than the previous analyses and new analytical methods have been incorporated over time. While this improved the overall quality of the information provided, it also means that individual reports should not be compared directly without fully understanding the processes used to develop the results.

Trends for suitable habitat are largely declining rangewide, with rates of loss varying by province and land allocation. Approximately 9,089,700 acres of spotted owl nesting/roosting habitat existed on Federal lands and 3,436,000 acres existed on non-federal lands at the beginning of the NWFP in 1994/1996 Davis and others (2016, pp.23-24). Two decades into the NWFP, Davis and others (2016, tables 6 and 7, pp. 21-22) reported a gross loss of about 650,200 acres of nesting/roosting habitat, representing about 7.2 percent of what was present in 1994/1996. Most of the losses (73 percent) occurred within the federally reserved LUAs, or a loss of about 7.5 percent of the habitat reserved by the NWFP; the majority of these losses were due to high severity fires within the Klamath Physiographic Provinces.

Some recruitment of nesting/roosting habitat was noted (Davis et al. 2016, p. 24). The recruitment of habitat in non-reserved areas led to a net increase in nesting/roosting habitat of 4.3

percent since 1993. Most of the gains occurred in the moister physiographic provinces (e.g., Coast Ranges and Western Cascades) however, there was also a large gain (13.5 percent) in the Oregon Eastern Cascades. Authors noted that habitat recruitment estimates have a higher level of uncertainty than estimates of habitat loss for reasons detailed in the NWFP 15-year monitoring report (Davis et al. 2011, pgs. 48 and 49). Although the spatial resolution of this new habitat map currently makes it unsuitable for tracking habitat effects at the scale of individual projects, the Service has evaluated the map for use in tracking provincial and rangewide habitat trends and now considers these data as the best available information on the distribution and abundance of extant spotted owl habitat within its range as of 2012 for Oregon and Washington, and California, when the base imagery was collected.

The Service also considers habitat effects that are documented through the section 7 consultation process since 1994. The analytical framework of these consultations focuses on the reserve and connectivity goals established by the NWFP land-use allocations (USDA FS/USDI BLM 1994a), with effects expressed in terms of changes in suitable northern spotted owl habitat within those land-use allocations.

In February 2013, the Service adopted the 2006/07 satellite imagery data on spotted owl habitat as the new rangewide habitat baseline for Federal lands which effectively resets the timeframe for establishing changes in the distribution and abundance of spotted owl habitat. These data were refreshed in May of 2017 to reflect the 2012 remotely-sensed layer utilized in Davis et al., 2016. Until these data are refreshed, the assessment of local, provincial and rangewide spotted owl habitat status in this and future Opinions as well as Biological Assessments will rely on these habitat data associated with 2012 imagery to characterize changes in the status of spotted owl habitat.

Service's Consultation Database

To update information considered in 2001 (USDI FWS 2001), the Service designed the Consultation Effects Tracking System database in 2002, which recorded impacts to northern spotted owls and their habitat at different spatial and temporal scales. In 2011, the Service replaced the Consultation Effects Tracking System with the Consulted on Effects Database located in the Service's Environmental Conservation Online System (ECOS). The ECOS Database corrected technical issues with the Consultation Effects Tracking System. Data are currently entered into the ECOS Database under various categories including; land management agency, land-use allocation, physiographic province, and type of habitat affected.

Rangewide Consultation Effects: 1994 to May 20, 2020

Between 1994 and May 20, 2020, the Service has consulted on the proposed removal/downgrade of approximately 236,913 acres of federal nesting/roosting habitats (Table A-1) or about 2.6 percent of the 9.09 million acres of northern spotted owl nesting/roosting habitat estimated by Davis et al. (2016, p. 21) to have occurred on Federal lands in 1994. These changes in suitable northern spotted owl habitat are consistent with the expectations for implementation of the NWFP, which anticipated a rate of habitat harvested at 2.5 percent per decade (USDA FS/USDI BLM 1994a).

The Service also tracks habitat changes on non-NWFP lands through consultations including

long-term Habitat Conservation Plans, Safe Harbor Agreements, or Tribal Forest Management Plans. Consultations conducted since 1994 have documented the eventual combined reduction of about 523,079 acres of habitat on non-NWFP lands. Most of the losses on non-NWFP lands have yet to be realized because they are part of long-term management plans.

In 2017, the Service updated the nesting /roosting habitat baseline which impacts are evaluated against, based on the 2012 habitat layer documented in Davis et al. (2016, p. 21) which is the most current evaluation of spotted owl habitat. The acre values for the Service's 2012 baseline in Table A-2 varies slightly from the acre values in Davis et al. (2016, p. 21), with the total acre variation being 0.09 percent. Davis et al. (2016, p. 21) rounded to the nearest 100 acres, but this does not explain all the variation. In 2016, the BLM in Oregon changed their land use allocations. Therefore, the 2012 base habitat layer was divided by different land use allocations representing reserves and non-reserved lands than was used to produce Davis et al. (2016, p. 21). Due to raster data (2012 habitat layer) overlaid on polygons (land use allocations representing reserves and non-reserved lands) there is some error in the identification of acres. The use of a different polygon layer, than used for the Davis et al. (2016, p. 21) land use allocations, resulted in different physiographic province reserves and non-reserved lands habitat acres. The combination of errors is extremely small and is still the best available information to use. This highlights that this data is to be used at a landscape level and may not be appropriate at the finer local scale. Since 2012, the acres reported as removed/downgraded are summarized by origin and by province (Table A-2).

**Table A-1: Spotted owl Take/Effect Reports Table A - Rangewide summary of effects to northern spotted owl nesting/roosting habitat[1] (acres) documented through ESA section 7 consultations or technical assistance reports; 1994 to Present.**

**May 20 10:40:40 MDT 2020**

| Land Ownership | Consulted On Habitat Changes[2] | | Other Habitat Changes[3] | |
|---|---|---|---|---|
| | Removed/ Downgraded | Maintained/ Improved | Removed/ Downgraded | Maintained/ Improved |
| **USFS, BLM, and NPS** | 236,913 | 660,178 | 408,416 | 148,610 |
| **Bureau of Indian Affairs / Tribes** | 114,574 | 28,372 | 3,176 | 0 |
| **Habitat Conservation Plans/Safe Harbor Agreements** | 339,692 | 14,539 | N/A | N/A |
| **Other Federal, State, County, Private Lands** | 68,813 | 28,447 | 2,607 | 0 |
| **Total Changes** | **759,992** | **731,536** | **414,199** | **148,610** |

Notes:

1. Northern spotted owl suitable habitat includes nesting/roosting habitat, and foraging habitat. Nesting/roosting habitat supports all life-history functions for spotted owls including foraging, and is sometimes referred to as nesting, roosting, and foraging habitat (NRF). Foraging-only habitat is a separate category that can include more open and fragmented forests, and does not provide structures for nesting/roosting. Habitat effects summarized in this table are all classified as impacts to nesting/roosting habitats. Impacts to foraging-only habitat are tracked separately.
2. Includes effects documented through ESA section 7 consultations for the period from 1994 to 6/26/2001 (USFWS 2001) and all subsequent effects reported in the USFWS Tracking and Integrated Logging System - Northern Spotted Owl Consultation Effects Database (web application and database).
3. Includes effects to spotted owl nesting/roosting habitat documented through technical assistance reports resulting from wildfires and other natural causes, private timber harvest, and/or land exchanges not associated with ESA section 7 consultations.

**Table A-2. Spotted owl Take/Effect Reports Table B - Summary of northern spotted owl nesting/roosting[1] habitat (acres) removed or downgraded as documented through ESA section 7 consultations on Federal lands. Environmental baseline and summary of effects by state, province, and land use function from 2012 to present.**
**May 20 10:44:07 MDT 2020**

| State | Physiographic Province2 | Evaluation Baseline (2012)[3] | | | Nesting/Roosting Habitat Removed/Downgraded[4] | | | | | | | % Provincial Baseline Affected | % Range-wide Effects |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Land Management Effects | | | Habitat Loss from Natural Events | | | Total NR removed/ downgraded | | |
| | | NR Acres in Reserves | NR Acres in Non-Reserves | Total NR Acres | Reserves[5] | Non-Reserves[6] | Total | Reserves | Non-Reserves | Total | | | |
| WA | Eastern Cascades | 554,786 | 224,876 | 779,662 | 1,563 | 55 | 1,618 | 63,931 | 0 | 63,931 | 65,549 | 8.41 | 28.42 |
| | Olympic Peninsula | 714,555 | 23,084 | 737,639 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| | Western Cascades | 957,314 | 212,325 | 1,169,639 | 15 | 188 | 203 | 0 | 0 | 0 | 203 | 0.02 | 0.09 |
| | Western Lowlands | 12,964 | 3 | 12,967 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| OR | Cascades East | 206,719 | 133,080 | 339,799 | 1,199 | 3,245 | 4,444 | 2,159 | 1,528 | 3,687 | 8,131 | 2.39 | 3.53 |
| | Cascades West | 1,425,026 | 949,045 | 2,374,071 | 4,527 | 9,936 | 14,463 | 13,129 | 3,384 | 16,513 | 30,976 | 1.3 | 13.43 |
| | Coast Range | 468,575 | 38,898 | 507,473 | 2,310 | 1,809 | 4,119 | 0 | 0 | 0 | 4,119 | 0.81 | 1.79 |
| | Klamath Mountains | 706,840 | 227,726 | 934,566 | 6,997 | 9,678 | 16,675 | 22,289 | 23,055 | 45,344 | 62,019 | 6.64 | 26.89 |
| | Willamette Valley | 3,688 | 3,938 | 7,626 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CA | Cascades | 120,067 | 89,316 | 209,383 | 0 | 174 | 174 | 0 | 0 | 0 | 174 | 0.08 | 0.08 |
| | Coast | 113,857 | 9,999 | 123,856 | 0 | 0 | 0 | 0 | 2,940 | 2,940 | 2,940 | 2.37 | 1.27 |
| | Klamath | 1,143,050 | 622,027 | 1,765,077 | 387 | 630 | 1,017 | 15,528 | 39,973 | 55,501 | 56,518 | 3.2 | 24.51 |
| **Total** | | **6,427,441** | **2,534,317** | **8,961,758** | **16,999** | **25,715** | **42,714** | **117,036** | **70,880** | **187,916** | **230,630** | **2.57** | **100** |

Notes:

1. Northern spotted owl suitable habitat includes nesting/roosting habitat, and foraging habitat. Nesting/roosting habitat supports all life-history functions for spotted owls including foraging, and is sometimes referred to as nesting, roosting, and foraging habitat (NRF). Foraging-only habitat is a separate category that can include more open and fragmented forests, and does not provide structures for nesting/roosting. Habitat effects summarized in this table are all classified as impacts to nesting/roosting habitat. Impacts to foraging-only habitat are tracked separately.
2. Defined in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) as Recovery Units as depicted on page A-3.
3. Spotted owl nesting/roosting (NR) habitat on Federal lands (includes USFS, BLM, NPS, DoD, USFWS) based on GIS data developed for the Northwest Forest Plan 20-year monitoring report for northern spotted owl habitat as reported by Davis et al. 2016 (PNW-GTR-929). Nesting/roosting habitat acres are approximate values based on 2012 satellite imagery. Values reported here may vary slightly from values reported in PNW-GTR-929.
4. Estimated nesting/roosting habitat removed or downgraded from land management (e.g., timber sales) or natural events (e.g., wildfires) as documented through section 7 consultation or technical assistance. Effects reported here include acres removed or downgraded from 2012 to present.
5. Reserve land use allocations intended to provide spotted owl demographic support include Late-Successional Reserves identified in the Northwest Forest Plan on National Forests, designated Wilderness, and other Congressionally-reserved lands. Reserves on BLM lands in western Oregon managed under the 2016 revised Land and Resource Management Plans include Late-Successional Reserves, Congressionally-

reserved lands, National Landscape Conservation System lands, and some District Designated Reserves (e.g., Areas of Critical Environmental Concern).

**6.** Non-reserve lands intended to provide spotted owl dispersal connectivity between reserves include USFS and BLM designations for timber production (matrix and harvest land base designations), Adaptive Management Areas, and other non-reserved land use designations.

Recently, the Service modified the database input to account for effects to the habitats that could be used as foraging, but that lack the age or structural characteristics of habitats used for nesting and roosting (NR). This distinction may not be made in all consultations. These data represent effects as reported in individual consultations and likely do not represent the entirety of impacts to foraging habitat within critical habitat since 2012. For many projects, affected foraging likely is captured within the "NR" acres as foraging habitat was lumped into "nesting/roosting/foraging habitat" at the time of consultation. Table A-3 summarizes the acres of foraging habitat removed or downgraded.

**Table A-3. Spotted owl Take/Effect Reports Table B2 - Summary of northern spotted owl foraging habitat[1] (acres) removed or downgraded as documented through ESA section 7 consultations on Federal lands. Summary of effects by state, province, and land use function from 2012 to present.**

**May 20 11:02:05 MDT 2020**

| State | Physiographic Province[2] | Foraging Habitat Removed/Downgraded[3] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Land Management Effects | | | Habitat Loss from Natural Events | | | Total Foraging Habitat removed/ downgraded |
| | | Reserves[4] | Non-Reserves[5] | Total | Reserves | Non-Reserves | Total | |
| WA | Eastern Cascades | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Olympic Peninsula | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Western Cascades | 0 | 10 | 10 | 0 | 0 | 0 | 10 |
| | Western Lowlands | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| OR | Cascades East | 124 | 2,738 | 2,862 | 0 | 62 | 62 | 2,924 |
| | Cascades West | 263 | 1,417 | 1,680 | 0 | 0 | 0 | 1,680 |
| | Coast Range | 0 | 1,934 | 1,934 | 0 | 0 | 0 | 1,934 |
| | Klamath Mountains | 242 | 3,688 | 3,930 | 0 | 0 | 0 | 3,930 |
| | Willamette Valley | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CA | Cascades | 571 | 248 | 819 | 0 | 0 | 0 | 819 |
| | Coast | 0 | 1 | 1 | 0 | 7,711 | 7,711 | 7,712 |
| | Klamath | 1,454 | 655 | 2,109 | 8,558 | 9,916 | 18,474 | 20,583 |
| **Total** | | **2,654** | **10,691** | **13,345** | **8,558** | **17,689** | **26,247** | **39,592** |

Notes:

1. Northern spotted owl suitable habitat includes nesting/roosting habitat, and foraging habitat. Nesting/roosting habitat supports all life-history functions for spotted owls including foraging, and is sometimes referred to as nesting, roosting, and foraging habitat (NRF). Foraging-only habitat is a separate category that can include more open and fragmented forests, and does not provide structures for nesting/roosting. Habitat effects summarized in this table are all classified as impacts to nesting/roosting habitat. Impacts to foraging-only habitat are tracked separately.
2. Defined in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) as Recovery Units as depicted on page A-3.
3. Spotted owl nesting/roosting (NR) habitat on Federal lands (includes USFS, BLM, NPS, DoD, USFWS) based on GIS data developed for the Northwest Forest Plan 20-year monitoring report for northern spotted owl habitat as reported by Davis et al. 2016 (PNW-GTR-929). Nesting/roosting habitat acres are approximate values based on 2012 satellite imagery. Values reported here may vary slightly from values reported in PNW-GTR-929. Estimated nesting/roosting habitat removed or downgraded from land management (e.g., timber sales) or natural events (e.g., wildfires) as documented through section 7 consultation or technical assistance. Effects reported here include acres removed or downgraded from 2012 to present.
4. Reserve land use allocations intended to provide spotted owl demographic support include Late-Successional Reserves identified in the Northwest Forest Plan on National Forests, designated Wilderness, and other Congressionally-reserved lands. Reserves on BLM lands in western Oregon managed under the 2016 revised Land and Resource Management Plans include Late-Successional Reserves, Congressionally-reserved lands, National Landscape Conservation System lands, and some District Designated Reserves (e.g., Areas of Critical Environmental Concern).

5. Non-reserve lands intended to provide spotted owl dispersal connectivity between reserves include USFS and BLM designations for timber production (matrix and harvest land base designations), Adaptive Management Areas, and other non-reserved land use designations.

Other Past Habitat Trend Assessments

In 2005, the Washington Department of Wildlife released the report, “An Assessment of Spotted Owl Habitat on Non-Federal Lands in Washington between 1996 and 2004” (Pierce et al. 2005). This study estimates the amount of spotted owl habitat in 2004 on lands affected by state and private forest practices. The study area is a subset of the total Washington forest practice lands, and statistically-based estimates of existing habitat and habitat loss due to fire and timber harvest are provided. In the 3.2-million acre study area, Pierce et al. (2005) estimated there was 816,000 acres of suitable spotted owl habitat in 2004, or about 25 percent of their study area. Based on their results, Pierce et al. (2005) estimated there were less than 2.8 million acres of spotted owl habitat in Washington on all ownerships in 2004. Most of the suitable owl habitat in 2004 (56%) occurred on Federal lands, and lesser amounts were present on state-local lands (21%), private lands (22%) and tribal lands (1%). Most of the harvested spotted owl habitat was on private (77%) and state-local (15%) lands. A total of 172,000 acres of timber harvest occurred in the 3.2 million-acre study area, including harvest of 56,400 acres of suitable spotted owl habitat. This represented a loss of about 6 percent of the owl habitat in the study area distributed across all ownerships (Pierce et al. 2005). Approximately 77 percent of the harvested habitat occurred on private lands and about 15 percent occurred on State lands. Pierce and others (2005) also evaluated suitable habitat levels in 450 spotted owl management circles (based on the provincial annual median spotted owl home range). Across their study area, they found that owl circles averaged about 26 percent suitable habitat in the circle across all landscapes. Values in the study ranged from an average of 7 percent in southwest Washington to an average of 31 percent in the east Cascades, suggesting that many owl territories in Washington are significantly below the 40 percent suitable habitat threshold used by the State as a viability indicator for spotted owl territories (Pierce et al. 2005).

Moeur et al. 2005 estimated an increase of approximately 1.25 to 1.5 million acres of medium and large older forest (greater than 20 inches dbh, single and multi-storied canopies) on Federal lands in the NWFP area between 1994 and 2003. The increase occurred primarily in the lower end of the diameter range for older forest. In the greater than 30 inch dbh size class, the net area increased by only an estimated 102,000 to 127,000 acres (Moeur et al. 2005). The estimates were based on change-detection layers for losses due to harvest and fire and re-measured inventory plot data for increases due to ingrowth. Transition into and out of medium and large older forest over the 10-year period was extrapolated from inventory plot data on a subpopulation of Forest Service land types and applied to all Federal lands. Because size class and general canopy layer descriptions do not necessarily account for the complex forest structure often associated with northern spotted owl habitat, the significance of these acres to northern spotted owl conservation remains unknown.

**Population Trends**

There are no estimates of the historical population size and distribution of spotted owls, although they are believed to have inhabited most old-growth forests throughout the Pacific Northwest prior to modern settlement (mid-1800s), including northwestern California (USDI FWS 1989,

pp. 2-17).

The current range of the spotted owl extends from southwest British Columbia through the Cascade Mountains, coastal ranges, and intervening forested lands in Washington, Oregon, and California, as far south as Marin County (USDI FWS 1990a, p. 26114). The range of the spotted owl is partitioned into 12 physiographic provinces (Figure A-1) based on recognized landscape subdivisions exhibiting different physical and environmental features (USDI FWS 1992a, p. 31). The spotted owl has become rare in certain areas, such as British Columbia, southwestern Washington, and the northern coastal ranges of Oregon.

Because the existing survey coverage and effort are insufficient to produce reliable rangewide estimates of population size, demographic data are used to evaluate trends in spotted owl populations. Analysis of demographic data can provide an estimate of the finite rate of population change ($\lambda$), which provides information on the direction and magnitude of population change. A $\lambda$ of 1.0 indicates a stationary population, meaning the population is neither increasing nor decreasing. A $\lambda$ of less than 1.0 indicates a decreasing population, and a $\lambda$ of greater than 1.0 indicates a growing population. Demographic data, derived from studies initiated as early as 1985, have been analyzed periodically to estimate trends in the populations of the spotted owl (Anderson and Burnham 1992; Burnham et al. 1994; Forsman et al. 1996; Anthony et al. 2006; Forsman et al. 2011; Dugger et al. 2016).

The most recent meta-analysis (Dugger et al. 2016) found continued declines in virtually all demographic parameters evaluated (Table A-4). Estimates of annual rates of population change, occupancy rates, and realized population change showed continuing declines across the range, and that the annual rate of decline was increasing in many areas, including southern Oregon and northern California. With the exception of treatment areas the Green Diamond Study Area (GDR-T) where removal of barred owls was initiated in 2009, Dugger et al. (2016, p. 70) reported that the populations in all study areas were declining, including those study areas that had been relatively stable in earlier analyses. Notably, the rate of realized population change for northern spotted owls in Cle Elum and the Olympic Peninsula demographic study areas in Washington showed a 60-70 percent decline over the past two decades. Lower rates were observed in the Oregon and California study areas where the realized rate of population change has shown a decline of 31-64 percent over the past two decades; the confidence intervals for some of the estimates of rate of population change slightly overlap zero, the results indicated a significant negative time trend at seven of the eleven study areas (Dugger et al. 2016, p. 70). These findings indicate that these populations are declining over time and the rate of decline is increasing.

The probability of occupancy has declined in all three states over the past two decades. Dugger et al. (2016, pp. 73-74); reported that occupancy rates in Washington declined from a range of 56 to100 percent in 1995, to a range of 11 to 26 percent in 2013. During this same time period, occupancy rates in Oregon declined from a range of 61 to 88 percent in 1995, to a range of 28 to 48 percent in 2013. In California, occupancy rates declined from a range of approximately 42 to 92 percent in 1993, to a range of 38 to 55 percent in 2013. This 2016 analysis was the first rangewide assessment of northern spotted owl population status to include estimates of occupancy dynamics (i.e. proportion of northern spotted owl territories occupied by a resident single or pair in a given year compared to the total number of territories surveyed), which revealed that territory occupancy of northern spotted owls has declined substantially in all 11 study areas since the early 1990s (Dugger et al. 2016, p. 79). The lowest occupancy rates were

observed in 2013 (the final year included in this study) in the Oregon Coast Ranges Study Area (28 percent) and at the 3 study areas in Washington (Olympic, Cle Elum, Rainier).

Two methods of estimating populations have been described - records of known sites and population modeling. As of July 1, 1994, there were 5,431 known site-centers of spotted owl pairs or resident singles: 851 sites (16 percent) in Washington, 2,893 sites (53 percent) in Oregon, and 1,687 sites (31 percent) in California (USDI FWS 1995, p. 9495). The actual number of currently occupied spotted owl locations across the range is unknown because many areas remain unsurveyed (USDI FWS 2011b, p. A-2). In addition, many historical sites are no longer occupied because spotted owls have been displaced by barred owls, timber harvest, or severe fires, and it is possible that some new sites have been established due to reduced timber harvest on Federal lands since 1994. The totals above represent the cumulative number of locations recorded in the three states, not population estimates. Estimated populations were modeled during the 2012 critical habitat designation which projected a steady-state rangewide population size of roughly 3,400 female northern spotted owls. Population sizes varied regionally from low in the north, especially the northwest (e.g., about 100 in the North Coast Olympics and West Cascades North modeling regions), to high in parts of southern Oregon and northern California (e.g. about 750 each in the Inner California Coast, Klamath East, Klamath West, Redwood Coast, and West Cascades South modeling regions) (Dunk et al., 2012, p. 64). These estimates likely over represent the numbers of females as this modeling effort does not reflect rates of declines from 2008 - 2011 (as described in Dugger et al. 2016). Additionally, the actual number of currently occupied spotted owl locations across the range is unknown because many areas remain un-surveyed (USDI FWS 2011a, p. A-2) and many historical sites are no longer occupied because spotted owls have been displaced by barred owls, timber harvest, or severe fires. Other factors such as impacts of anticoagulant rodenticides have likely negatively affected localized spotted owl populations (Gabriel et al. 2018, p. 6). Another unmeasured factor might include the possibility that some new sites have been established due to reduced timber harvest on Federal lands since 1994.

Table A-4. **Summary of most recent spotted owl population trends from in demographic study areas in Washington, Oregon, and California 1985-2013 (Derived from Dugger et al. 2016, Tables 2, 4 and 25).**

| Study Area [a] | Fecundity | Apparent Survival | Occupancy Rates | Lamda | Mean Lamda | % Pop Size |
|---|---|---|---|---|---|---|
| Washington | | | | | | |
| CLE | Declining | Declining | Declining | No trend | 0.916 | –77% |
| RAI | No trend | Declining | Declining | No trend | 0.953 | –61% |
| OLY | No trend | No trend | Declining | No trend | 0.961 | –59% |
| Oregon | | | | | | |
| COA | Declining | No trend | Declining | Declining | 0.949 | –64% |
| HJA | Declining | Declining | Declining | Declining | 0.965 | –47% |
| TYE | Declining | Declining | Declining | Declining | 0.976 | –31% |
| KLA | Declining | No trend | Declining | Declining | 0.972 | –34% |
| CAS | No trend | Declining | Declining | No trend | 0.963 | –44% |
| California | | | | | | |
| NWC | Declining | Declining | Declining | Declining | 0.970 | –55% |
| HUP | Declining | Declining | Declining | Declining | 0.977 | –32% |
| GDR-CB | Declining | Declining | Declining | Declining | 0.988 | –31% |
| GDR-TB | Declining | Declining | Declining | Declining | 0.961 | –26% |
| GDR-CA | ** | ** | Declining | ** | 0.878 | –41% |
| GDR-TA | ** | ** | N/A [c] | ** | 1.030 | –9% |

[c] Data used for occupancy modeling in the GDR study area excluded treatment areas after Barred Owl removals began in 2009.

** Too few years since Barred Owl removal to evaluate a trend.

In the northern-most portion of the range in British Columbia, few spotted owls are remaining. Chutter et al. (2004, p. v) suggested immediate action was required to improve the likelihood of recovering the spotted owl population in British Columbia. In 2007, personnel in British Columbia captured and brought into captivity the remaining 16 known wild spotted owls (USDI FWS 2011b, p. A-6). Prior to initiating the captive-breeding program, the population of spotted owls in Canada was declining by as much as 10.4 percent per year (Chutter et al. 2004, p. v). As of 2016, this program was comprised of 17 spotted owls, eight of which were born in captivity (British Columbia 2017, p. 1). The program is targeted produce annually up to 20 captive-born owls ready for release back into the wild until the population reaches 200; the first year of release expected to occur in the spring of 2018. The amount of previous interaction between spotted owls in Canada and the United States is unknown.

## Spotted Owl Critical Habitat

### Legal Status

The final rule designating critical habitat for the northern spotted owl was published on December 4, 2012 (USDI FWS 2012a), and became effective on January 3, 2013. Critical habitat for the northern spotted owl now includes approximately 9,577,969 acres in 11 units and 60 subunits in California, Oregon, and Washington.

Designation of critical habitat serves to identify those lands that are necessary for the conservation and recovery of the listed species. In this case, the Service's primary objective in

designating critical habitat was to identify capable and existing essential northern spotted owl habitat and highlight specific areas where management of the northern spotted owl and its habitat should be given highest priority. The expectation of critical habitat is to ameliorate habitat-based threats. The recovery of the northern spotted owl requires habitat conservation in concert with the implementation of recovery actions that address other, non-habitat-based threats to the species, including the barred owl (USDI FWS 2012a, p. 71879). The conservation role of northern spotted owl critical habitat is to "adequately support the life-history needs of the species to the extent that well-distributed and inter-connected northern spotted owl nesting populations are likely to persist within properly functioning ecosystems at the critical habitat unit and range-wide scales" (USDI FWS 2012a, p. 71938). The specific conservation roles of the subunits included in the action area are described below in the Environmental Baseline.

**Physical or Biological Features and Primary Constituent Elements**

When designating critical habitat, the Service considers "the physical or biological features [PBFs] essential to the conservation of the species and which may require special management considerations or protection" (50 CFR §424.12; USDI FWS 2012a, p. 71897). "These include, but are not limited to: (1) space for individual and population growth and for normal behavior; (2) food, water, air, light, minerals, or other nutritional or physiological requirements; (3) cover or shelter; (4) sites for breeding, reproduction, or rearing (or development) of offspring; and (5) habitats that are protected from disturbance or are representative of the historical, geographical, and ecological distributions of a species" (USDI FWS 2012a, p. 71897). The final critical habitat rule states that "for the northern spotted owl, the physical or biological features essential to the conservation of the species are forested areas that are used or likely to be used for nesting, roosting, foraging, or dispersing" (USDI FWS 2012a, p. 71897). The final critical habitat rule for the northern spotted owl provides an in-depth discussion of the PBFs, which may be referenced for further detail (USDI FWS 2012a, pp. 71897-71906).

The final rule for critical habitat defines the primary constituent elements (PCEs) as the specific elements of the PBFs that are considered essential to the conservation of the northern spotted owl and are those elements that make areas suitable as nesting, roosting, foraging, and dispersal habitat (USDI FWS 2012a, p. 71904). The PCEs should be arranged spatially such that it is favorable to the persistence of populations, survival, and reproductive success of resident pairs, and survival of dispersing individuals until they are able to recruit into a breeding population (USDI FWS 2012a, p. 71904). Within areas essential for the conservation and recovery of the northern spotted owl, the Service has determined that the PCEs are:

i) Forest types that may be in early-, mid-, or late-seral stages and that support the northern spotted owl across its geographic range;
ii) Habitat that provides for nesting and roosting;
iii) Habitat that provides for foraging;
iv) Habitat to support the transience and colonization phases of dispersal, which in all cases would optimally be composed of nesting, roosting, or foraging habitat (PCEs 2 or 3), but which may also be composed of other forest types that occur between larger blocks of nesting, roosting, or foraging habitat (USDI FWS 2012, pp. 72051-72052).

In 2016, the Service returned to the use of statutory reference of PBFs rather than PCEs when evaluating and discussing the availability and function of, as well as the effects to the attributes of critical habitat in the adverse modification analysis (USDI FWS and USDC NOAA 2016, p.

2716). Some critical habitat subunits may contain all of the PBFs and support multiple life history requirements of the northern spotted owl, while some subunits may contain only those PBFs necessary to support the species particular use of that habitat. All of the areas designated as critical habitat, however, do contain PCE 1, forest type. As described in the final rule, PCE 1 always occurs in concert with at least one other PCE (PCE 2, 3, or 4; USDI FWS 2012a, p. 72051). Northern spotted owl critical habitat does not include meadows, grasslands, oak woodlands, aspen woodlands, or manmade structures and the land upon which they are located (USDI FWS 2012a, p. 71918).

*PCE 1: Forest Types*

The primary forest types that support the northern spotted owl are: Sitka spruce, western hemlock, mixed conifer, mixed evergreen, grand fir, Pacific silver fir, Douglas-fir, white fir, Shasta red fir, redwood/Douglas-fir, and moister ponderosa pine (USDI FWS 2012a, p. 72051).

*PCE 2: Nesting and Roosting Habitat*

Nesting and roosting habitat habitats provide structural features for nesting, protection from adverse weather conditions, and cover to reduce predation risk for adults and young. Unlike foraging habitat, structural conditions of nesting roosting habitats do not vary much across the range. The final rule describes characteristics associated with nesting and roosting habitats sufficient for foraging by territorial pairs, moderate to high canopy cover (60 to over 80 percent), multilayered and multispecies canopies with large overstory trees (20 to 30 inches dbh), basal area greater than 240 square feet per acre, high diversity of tree diameters, high incidence of large live trees with various deformities (e.g., large cavities, broken tops, mistletoe infections, and other evidence of decadence), large snags and large accumulations of woody debris on the ground, and sufficient open space beneath the canopy for flight (USDI FWS 2012a, p. 72051). Nesting and roosting habitats will also function as foraging and dispersal habitat (FWS 2012a, p. 71884).

*PCE 3: Foraging Habitat*

Foraging habitat varies across the range, depending upon ecological conditions and disturbance regimes that influence vegetation structure and prey species distributions. Across most of the owl's range, nesting and roosting habitat is also foraging habitat, but in some regions (particularly in the southern portion of the range) northern spotted owls may additionally use other habitat types for foraging as well (differences in foraging habitats between ecological provinces are discussed below).

*PCE 4: Dispersal Habitat*

Northern spotted owl dispersal habitat is habitat that supports the transience and colonization phases of owl dispersal, and in all cases would optimally be composed of nesting, roosting, or foraging habitat (PCE 2 or 3), but which may also be composed of other forest types that occur between larger blocks of northern spotted owl nesting, roosting, or foraging habitat. In cases where nesting, roosting, or foraging habitats are insufficient to provide for dispersing or nonbreeding owls, the specific dispersal PCEs are: habitat supporting transience phase of dispersal (protection from avian predators, minimal foraging opportunities, younger and less diverse forests that provide some roosting structures and foraging opportunities) and habitat

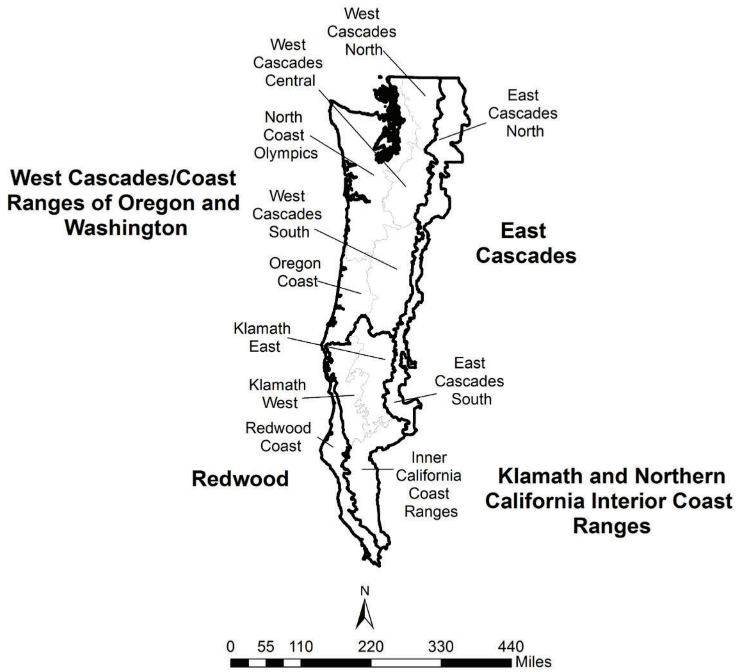
supporting the colonization phase of dispersal (nesting, roosting, and foraging habitat but in smaller amounts than needed to support a nesting pair) (USDI FWS 2012a, p. 72052).

**Zones of Habitat Associations used by Northern Spotted Owls**

Differences in patterns of habitat associations used by the northern spotted owl across its range suggest four different broad zones of habitat use, which we characterize as the (1) West Cascades/Coast Ranges of Oregon and Washington, (2) East Cascades, (3) Klamath and Northern California Interior Coast Ranges, and (4) Redwood Coast (Figure A-3). We configured these zones based on a qualitative assessment of similarity among ecological conditions and habitat associations within the 11 different regions analyzed during the critical habitat designation process (see USDI FWS 2012a). These four zones capture the range in variation of some of the PBFs essential to the conservation of the northern spotted owl. Habitat modeling indicates that vegetation structure has a dominant influence on owl population performance, with habitat pattern and topography also contributing. High canopy cover, high density of large trees, high numbers of sub-canopy vegetation layers, and low to moderate slope positions are all important features. Summarized below are the PBFs for each of these four zones, emphasizing zone-specific features that are distinctive within the context of general patterns that apply across the entire range of the northern spotted owl.

*West Cascades/ Coast Range of Oregon and Washington* - This zone includes five regions west of the Cascade crest in Washington and Oregon (Western Cascades North, Central and South; North Coast Ranges and Olympic Peninsula; and Oregon Coast Ranges; USDI FWS 2011b, p. C–13). Climate in this zone is characterized by high rainfall and cool to moderate temperatures. Variation in elevation between valley bottoms and ridges is relatively low in the Coast Ranges, creating conditions favorable for development of contiguous forests. In contrast, the Olympic and Cascade ranges have greater topographic variation with many high-elevation areas supporting permanent snowfields and glaciers. Douglas-fir and western hemlock dominate forests used by northern spotted owls in this zone. Root diseases and wind-throw are important natural disturbance mechanisms that form gaps in forested areas. Flying squirrels (*Glaucomys sabrinus*) are the dominant prey, with voles and mice also representing important items in the northern spotted owl's diet.

**Figure A-3. Regions and zones of habitat associations used by northern spotted owls in Washington, Oregon, and California.**




*West Cascade/Coast Ranges of Oregon and Washington* - Nesting habitat in this zone is mostly limited to areas with large trees with defects such as mistletoe brooms, cavities, or broken tops. The subset of foraging habitat that is not nesting/roosting habitat generally had slightly lower values than nesting habitat for canopy cover, tree size and density, and canopy layering. Prey species (primarily the northern flying squirrel) in this zone are associated with mature to late-successional forests, resulting in small differences between nesting, roosting, and foraging habitats.

*East Cascades* -This zone includes the Eastern Cascades North and Eastern Cascades South regions (USDI FWS 2011b, p. C–13). This zone is characterized by a continental climate (cold, snowy winters and dry summers) and a high frequency of natural disturbance due to fires and outbreaks of forest insects and pathogens. Flying squirrels are the dominant prey species, but the diet of northern spotted owls in this zone also includes relatively large proportions of bushy-tailed woodrats (*Neotoma cinerea*), snowshoe hare (*Lepus americanus*), pika (*Ochotona princeps*), and mice (*Microtus spp*. (Forsman et al. 2001, pp. 144–145).

Our modeling indicates that habitat associations in this zone do not show a pattern of dominant influence by one or a few variables (USDI FWS 2011b, Appendix C). Instead, habitat association models for this zone included a large number of variables, each making a relatively modest contribution (20 percent or less) to the predictive ability of the model. The features that were most useful in predicting northern spotted owl habitat quality were vegetation structure and composition, and topography, especially slope position in the north. Other efforts to model habitat associations in this zone have yielded similar results (e.g., Garm et al. 2010, pp. 2048–2050; Loehle et al. 2011, pp. 25–28).

Relative to other portions of the northern spotted owls' range, nesting and roosting habitat in this zone includes relatively younger and smaller trees, likely reflecting the common usage of dwarf mistletoe (*Arceuthobium douglasii*) brooms (dense growths) as nesting platforms (especially in the north). Forest composition that includes high proportions of Douglas-fir is also associated with this nesting structure. Additional foraging habitat in this zone generally resembles nesting and roosting habitat, with reduced canopy cover and tree size, and reduced canopy layering. High prey diversity suggests relatively diverse foraging habitats are used. Topographic position was an important variable, particularly in the north, possibly reflecting competition from barred owls (Singleton et al. 2010, pp. 289, 292). Barred owls, which have been present for over 30 years in the northern portions of this zone, preferentially occupy valley-bottom habitats, possibly compelling northern spotted owls to establish territories on less productive, mid-slope locations (Singleton et al. 2010, pp. 289, 292).

*Klamath and Northern California Interior Coast Ranges* - This zone includes the Klamath West, Klamath East, and Interior California Coast regions (USDI FWS 2011b, p. C–13). This region in southwestern Oregon and northwestern California is characterized by very high climatic and vegetative diversity resulting from steep gradients of elevation, dissected topography, and large differences in moisture from west to east. Summer temperatures are high, and northern spotted owls occur at elevations up to 5,800 feet. The western portions of this zone support a diverse mix of mesic forest communities interspersed with drier forest types. Forests of mixed conifers and evergreen hardwoods are typical of the zone. The eastern portions of this zone have a Mediterranean climate with increased occurrence of the ponderosa pine. Douglas-fir/dwarf mistletoe is rarely used for nesting platforms in the western part of the northern spotted owl's range, but is commonly used in the east.

The prey base for northern spotted owls in this zone is correspondingly diverse, but dominated by dusky-footed woodrats, bushy-tailed woodrats, and flying squirrels. Northern spotted owls have been well studied in the western Klamath portion of this zone (Forsman et al. 2004, p. 217), but relatively little is known about northern spotted owl habitat use in the eastern portion and the California Interior Coast Range portion of the zone.

Our habitat association models for this zone suggest that vegetation structure and topographic features are nearly equally important in influencing owl population performance, particularly in the Klamath. High canopy cover, high levels of canopy layering, and the presence of very large dominant trees were all important features of nesting and roosting habitat. Compared to other zones, additional foraging habitat for this zone showed greater divergence from nesting habitat, with much lower canopy cover and tree size. Low to intermediate slope positions were strongly favored. In the eastern Klamath, the presence of Douglas-fir was an important compositional variable in our habitat model (USDI FWS 2011b, Appendix C).

*Redwood Zone* - This zone is confined to the northern California coast, and is represented by the Redwood Coast region (USDI FWS 2011b, p. C–13). It is characterized by a maritime climate with moderate temperatures and generally mesic conditions. Near the coast, frequent fog delivers consistent moisture during the summer. Terrain is typically low-lying (0 to 3,000 feet). Forest communities are dominated by redwood, Douglas-fir–tanoak (*Lithocarpus densiflorus*) forest, coast live oak (*Quercus agrifolia*), and tanoak series. Dusky footed woodrats are the dominant prey items for northern spotted owls in this zone.

Habitat association models for this zone diverged strongly from models for other zones. Topographic variables (slope position and curvature) had a dominant influence with vegetation structure having a secondary role. Low position on slopes was strongly favored, along with concave landforms.

Several studies of northern spotted owl habitat relationships suggest that stump-sprouting and rapid growth of redwood trees, combined with high availability of woodrats in patchy, intensively managed forests, enables northern spotted owls to occupy a wide range of vegetation conditions within the redwood zone. Rapid growth rates enable young stands to develop structural characteristics typical of older stands in other regions. Thus, relatively small patches of large remnant trees can also provide nesting habitat structure in this zone.

**Climate Change and Range-wide Spotted Owl Critical Habitat**

There is growing evidence that recent climate change has impacted a wide range of ecological systems (Stenseth et al. 2002, entire; Walther et al. 2002, entire; Ådahl et al. 2006, entire; Karl et al. 2009, entire; Moritz et al. 2012, entire; Westerling et al. 2011, p. S459; Marlon et al. 2012, p. E541). Climate change, combined with effects from past management practices, is exacerbating changes in forest ecosystem processes and dynamics to a greater degree than originally anticipated under the NWFP. Environmental variation affects all wildlife populations; however, climate change presents new challenges as systems may change beyond historical ranges of variability. In some areas, changes in weather and climate may result in major shifts in vegetation communities that can persist in particular regions. (See expanded discussion in environmental baseline section above).

Climate change will present unique challenges to the future of northern spotted owl populations and their habitats. Northern spotted owl distributions (Carroll 2010, entire) and population dynamics (Franklin et al. 2000, entire; Glenn et al. 2010, entire; Glenn et al. 2011a, entire) may be directly influenced by changes in temperature and precipitation. In addition, changes in forest composition and structure as well as prey species distributions and abundance resulting from climate change may impact availability of habitat across the historical range of the subspecies. The *2011 Northern Spotted Owl Revised Recovery Plan* provides a detailed discussion of the possible environmental impacts to the habitat of the northern spotted owl from the projected effects of climate change (USDI FWS 2011b, pp. III-5 to III-11).

Because both northern spotted owl population dynamics and forest conditions are likely to be influenced by large-scale changes in climate in the future, we have attempted to account for these influences in our designation of critical habitat by recognizing that forest composition may change beyond the range of historical variation, and that climate changes may have unpredictable consequences for both Pacific Northwest forests and northern spotted owls. Our critical habitat designation also recognizes that forest management practices that promote ecosystem health under changing climate conditions will be important for northern spotted owl conservation.

**Current Condition of Range-Wide Critical Habitat**

The current condition of critical habitat incorporates the effects of all past human activities and natural events that led to the present-day status of the habitat (USDI FWS/USDC NMFS 1998,

pg. 4-19). With the revision of spotted owl critical habitat, the rangewide condition has been "reset" as of December 4, 2012.

The Service updated the ECOS database to reflect the 2006/2007 habitat baseline developed for the NWFP 15-year monitoring report (Davis et al. 2011, Appendix D, Table D). Additional updates were made in May of 2017 to reflect 2012 imagery utilized in the 20-year NWFP monitoring report (Davis et al. 2016).

The Service's ECOS database indicates that as of May 20, 2020, approximately 4.89 million acres nesting/roosting (NR) habitat occur within the rangewide 9.577 million acres of spotted owl critical habitat (Table A-5, baseline data). Since the imagery date of 2012, an estimated 34,494 acres of NR habitat in critical habitat have been removed or downgraded range-wide (about .36 percent of the available nesting/roosting). The majority of these impacts originated in the Washington East Cascades, Oregon East and West Cascades, the Oregon and California Klamath Physiographic Provinces and the California Coastal Province. Rangewide, about 15,269 acres were associated with natural disturbances, and about 19,225 were associated with land management actions.

**Table A-5. Spotted owl Take/Effect Reports Table D - Designated northern spotted owl critical habitat. Summary of northern spotted owl nesting/roosting[1] habitat (acres) removed or downgraded as documented through ESA section 7 consultations. Summary of effects by state, province, and land use function from 2012 to present.**
**May 20 11:20:31 MDT 2020**

| | Physiographic Province[2] | Evaluation Baseline | | Nesting/Roosting Habitat Removed/Downgraded[5] | | | | | | | % Provincial Baseline Affected | % Range-wide Effects |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Land Management Effects | | | Habitat Loss from Natural Events | | | | | |
| | | Total Designated Critical Habitat Acres[3] | Nesting/Roosting Acres[4] | Reserves[6] | Non-Reserves[7] | Total | Reserves | Non-Reserves | Total | Total NR Acres Removed | | |
| WA | Eastern Cascades | 1,022,960 | 467,221 | 1,552 | 55 | 1,607 | 3,895 | 0 | 3,895 | 5,502 | 1.18 | 15.95 |
| | Olympic Peninsula | 507,165 | 211,373 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0.00 | 0.00 |
| | Western Cascades | 1,387,567 | 606,093 | 15 | 185 | 200 | 0 | 0 | 0 | 200 | 0.03 | 0.58 |
| OR | Cascades East | 529,652 | 187,798 | 893 | 2,501 | 3,394 | 1,003 | 195 | 1,198 | 4,592 | 2.45 | 13.31 |
| | Cascades West | 1,965,407 | 1,255,027 | 1,830 | 4,230 | 6,060 | 662 | 617 | 1,279 | 7,339 | 0.58 | 21.28 |
| | Coast Range | 1,151,874 | 483,846 | 96 | 854 | 950 | 0 | 0 | 0 | 950 | 0.20 | 2.75 |
| | Klamath Mountains | 911,681 | 542,119 | 2,109 | 4,068 | 6,177 | 2,517 | 2,727 | 5,244 | 11,421 | 2.11 | 33.11 |
| CA | Cascades | 243,205 | 97,248 | 0 | 114 | 114 | 0 | 0 | 0 | 114 | 0.12 | 0.33 |
| | Coast | 149,044 | 94,033 | 0 | 0 | 0 | 0 | 2,212 | 2,212 | 2,212 | 2.35 | 6.41 |
| | Klamath | 1,708,787 | 945,505 | 292 | 430 | 722 | 30 | 1,411 | 1,441 | 2,163 | 0.23 | 6.27 |
| **Total** | | **9,577,342** | **4,890,263** | **6,788** | **12,437** | **19,225** | **8,107** | **7,162** | **15,269** | **34,494** | **0.36%** | **100%** |

Notes:

1. Northern spotted owl suitable habitat includes nesting/roosting habitat, and foraging-only habitat. Nesting/roosting habitat supports all life-history functions for spotted owls including foraging, and is sometimes referred to as nesting, roosting, and foraging habitat. Foraging-only habitat is a separate category that can include more open and fragmented forests, and does not provide structures for nesting/roosting. Habitat effects summarized in this table are all classified as impacts to nesting/roosting habitats. Impacts to foraging-only habitat are tracked separately.
2. Defined in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011a) as Recovery Units as depicted on page A-3.
3. Northern spotted owl critical habitat as designated December 4, 2012 (77 FR 71876). Total designated critical habitat acres listed here (9,577,342 acres) are derived from GIS data, and vary slightly from the total acres (9,577,969 acres) listed in the Federal Register (-627 acres).
4. Spotted owl nesting/roosting (NR) habitat based on GIS data developed for the Northwest Forest Plan 20-year monitoring report by Davis et al. 2016 (PNW-GTR-929). NR habitat acres are approximate values based on 2012 satellite imagery.
5. Estimated nesting/roosting habitat removed or downgraded from land management (e.g., timber sales) or natural events (e.g., wildfires) as documented through section 7 consultation or technical assistance. Effects reported here include acres removed or downgraded from 2012 to present.
6. Reserve land use allocations intended to provide spotted owl demographic support include Late-Successional Reserves identified in the Northwest Forest Plan on National Forests, designated Wilderness, and other Congressionally-reserved lands. Reserves on BLM lands in western Oregon managed under the 2016 revised Land and Resource Management Plans include Late-Successional Reserves, Congressionally-reserved lands, National Landscape Conservation System lands, and some District Designated Reserves (e.g., Areas of Critical Environmental Concern).

7. Non-reserve lands intended to provide spotted owl dispersal connectivity between reserves include USFS and BLM designations for timber production (matrix and harvest land base designations), Adaptive Management Areas, and other non-reserved land use designations.

Recently, the Service modified the ECOS database input to account for effects to the habitats that could be used as foraging, but that lack the age or structural characteristics of habitats used for nesting and roosting. This distinction may not be made in all consultations. These data represent effects as reported in individual consultations and likely do not represent the entirety of impacts to foraging habitat within critical habitat since 2012. For many projects, affected foraging likely is captured within the NR acres as foraging habitat was lumped into "nesting/roosting/foraging habitat" at the time of consultation. Trends to date mirror impacts reported by Davis et al. 2016, where habitat reductions are disproportionally affecting reserved lands and the Oregon and Klamath Province (Table A-6).

**Table A-6: Spotted owl Take/Effect Reports Table D2 - Designated northern spotted owl critical habitat. Summary of northern spotted owl foraging habitat[1] (acres) removed or downgraded as documented through ESA section 7 consultations. Summary of effects by state, province, and land use function from 2012 to present.**
**May 20 12:25:39 MDT 2020**

| | Physiographic Province[2] | Foraging Habitat Removed/Downgraded[4] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Total Designated Critical Habitat Acres[3] | Land Management Effects | | | Habitat Loss from Natural Events | | | Total Foraging Habitat removed/ downgraded |
| | | | Reserves[5] | Non-Reserves[6] | Total | Reserves[5] | Non-Reserves[6] | Total | |
| WA | Eastern Cascades | 1,022,960 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Olympic Peninsula | 507,165 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Western Cascades | 1,387,567 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| OR | Cascades East | 529,652 | 0 | 29 | 29 | 0 | 0 | 0 | 29 |
| | Cascades West | 1,965,407 | 263 | 687 | 950 | 0 | 0 | 0 | 950 |
| | Coast Range | 1,151,874 | 0 | 441 | 441 | 0 | 0 | 0 | 441 |
| | Klamath Mountains | 911,681 | 242 | 1,789 | 2,031 | 0 | 0 | 0 | 2,031 |
| CA | Cascades | 243,205 | 98 | 91 | 189 | 0 | 0 | 0 | 189 |
| | Coast | 149,044 | 0 | 1 | 1 | 0 | 4,688 | 4,688 | 4,689 |
| | Klamath | 1,708,787 | 1,449 | 523 | 1,972 | 772 | 133 | 905 | 2,877 |
| **Total** | | **9,577,342** | **2,052** | **3,561** | **5,613** | **772** | **4,821** | **5,593** | **11,206** |

Notes:

1. Northern spotted owl suitable habitat includes nesting/roosting habitat, and foraging-only habitat. Nesting/roosting habitat supports all life-history functions for spotted owls including foraging, and is sometimes referred to as nesting, roosting, and foraging habitat. Foraging-only habitat is a separate category that can include more open and fragmented forests, and does not provide structures for nesting/roosting. Habitat effects summarized in this table are all classified as impacts to foraging-only habitat. Impacts to nesting/roosting habitat are tracked separately. Environmental baseline information for foraging habitat as a separate habitat category is not available at a provincial scale.
2. Defined in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) as Recovery Units as depicted on page A-3.
3. Northern spotted owl critical habitat as designated December 4, 2012 (77 FR 71876). Total designated critical habitat acres listed here (9,577,342 acres) are derived from GIS data, and vary slightly from the total acres (9,577,969 acres) listed in the Federal Register (-627 acres).
4. Estimated foraging-only habitat removed or downgraded from land management (e.g., timber sales) or natural events (e.g., wildfires) as documented through ESA section 7 consultations or technical assistance. Effects reported here include acres removed or downgraded from 2012 to present.
5. Reserve land use allocations intended to provide spotted owl demographic support include Late-Successional Reserves identified in the Northwest Forest Plan on National Forests, designated Wilderness, and other Congressionally-reserved lands. Reserves on BLM lands in western Oregon managed under the 2016 revised Land and Resource Management Plans include Late-Successional Reserves, Congressionally-reserved lands, National Landscape Conservation System lands, and some District Designated Reserves (e.g., Areas of Critical Environmental Concern).

6. Non-reserve lands intended to provide spotted owl dispersal connectivity between reserves include USFS and BLM designations for timber production (matrix and harvest land base designations), Adaptive Management Areas, and other non-reserved land use designations.

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**Associated Federal Register Documents**

55 FR 26114: Determination of Threatened Status for the Northern Spotted Owl. Final Rule. Published in the Federal Register on January 26, 1990. 26114-26194.

57 FR 1796: Endangered and Threatened Wildlife and Plants; determination of critical habitat for the northern spotted owl. Final Rule. Published in the Federal Register on January 15, 1992. 1796-1838.

58 FR 14248: Final Rule To List the Mexican Spotted Owl as a Threatened Species. Final Rule. Published in the Federal Register on March 16, 1993. 14248-14271.

73 FR 29471: Proposed Revised Designation of Critical Habitat for the Northern Spotted Owl (*Strix occidentalis caurina*). Proposed rule. In addition, this document announced that the Final Recovery Plan for the Northern Spotted Owl is available. Published in the Federal Register on May 21, 2008. 29471-29477.

73 FR 47326: Revised Designation of Critical Habitat for the Northern Spotted Owl; Final Rule. Published in the Federal Register on Federal Register on August 13, 2008. 47326-47522.

76 FR 38575: Revised Recovery Plan for the Northern Spotted Owl (*Strix occidentalis caurina*). Notice of document availability: revised recovery plan. Published in the Federal Register on July 1, 2011. 38575-38576.

76 FR 63719: 12-Month Finding on a Petition To List a Distinct Population Segment of the Red Tree Vole as Endangered or Threatened. Proposed Rule. Published in the Federal Register on October 13, 2011. 63720-63762.

77 FR 71876: Designation of Revised Critical Habitat for the Northern Spotted Owl. Final Rule. Published in the Federal Register on December 4, 2012. 71876-72068.

78 FR 57171: Experimental Removal of Barred Owls To Benefit Threatened Northern Spotted Owls; Record of Decision for Final Environmental Impact Statement. Notice of availability September 17, 2013. 57171-57173.

80 FR 19259. 90-Day Findings on 10 Petitions. Notice of petition findings and initiation of status reviews. Published in the Federal Register on April 10, 2015. 19259-72068.

# APPENDIX B: PROJECT DESIGN CRITERIA (PDC) (Copied from the Assessment)

Project design criteria (PDC) are measures applied to project activities designed to minimize potential detrimental effects to proposed or listed species. The PDCs in this Appendix include the detailed seasonal restrictions for spotted owls. PDC for disturbance are intended to reduce disturbance to nesting spotted owls occupied spotted owl nest sites. Sites are assumed occupied unless surveys or habitat conditions indicate otherwise.

The seasonal or daily restrictions listed below may be waived at the discretion of the decision maker if necessary to protect public safety (as in the case of emergency road repairs or hazard tree removal). Emergency consultation with the Service will then be initiated in such cases, where appropriate.

Any of the following PDC may be waived in a particular year if nesting or reproductive success surveys conducted according to the U.S. Fish and Wildlife Service endorsed survey guidelines reveal that spotted owls are non-nesting or that no young are present that year. Waivers are only valid until March 1 of the following year. Previously known sites/ activity centers are assumed occupied until protocol surveys indicate otherwise.

## Disruption and Disturbance Distances

A **disruption distance** is the distance within which the effects to listed species from noise, or mechanical movement associated with an action is expected to exceed the level of discountable or insignificant. Thus, within the disruption distance, actions occurring within the nesting season are expected to *adversely affect* listed species. Unit wildlife biologists may increase, but may not decrease, these disruption distances and still comply with the standards of this consultation. Within the disruption distance, activities occurring during the critical breeding period could significantly disrupt the normal behavior pattern of individual animals or breeding pairs (USDI FWS 2004).

A **disturbance distance** is the distance within which the effects to listed species from noise, human intrusion, and mechanical movement associated with an action is expected to be discountable or insignificant and adverse effects will not be expected. Effects are expected to be "insignificant" or "discountable" beyond the disruption distance and up to the disturbance distance. Thus, between the disruption distance and disturbance distance recommendations, effects are not expected to adversely affect listed species. To correctly apply the standards of this assessment to individual animals or breeding pairs, the unit wildlife biologist may increase or decrease these disturbance distances in accordance with the best available scientific information and site-specific conditions. Beyond the disturbance distance recommendations, no effects to listed species are expected.

During the critical breeding period, activities occurring within the disruption distances, shown in **Table B-1** from occupied spotted owl sites, and unsurveyed NRF habitat, could cause injury by significantly disrupting the normal behavior pattern of individual animals or breeding pairs. Use of these recommended distances with the project design criteria listed below will minimize effects to listed species from disruption.

**Spotted Owl Seasonal Restrictions**

Distances described in Table B-1 to a known occupied spotted owl nest tree or fledging locations, but if no current survey information is available then distances are from the edge of the most recent nest patch.

**Table B-1 – Spotted Owl Seasonal Restrictions (content adopted from USDI FWS 2016 USDI FWS 2016b; Table 227, pp. 597-600).**

| Project Activity | Disruption Distance – Mandatory Seasonal Restrictions | Disturbance Distance – Potential Extension |
|---|---|---|
| | | March 1 – Sept. 30 |
| Light maintenance (*e.g.*, road brushing and grading) at campgrounds, administrative facilities, and heavily-used roads | *No Seasonal Restriction* | ≤ 0.25 mile |
| Log hauling on heavily-used roads | *No Seasonal Restriction* | ≤ 0.25 mile |
| Chainsaws (includes felling hazard/danger trees) | Not allowed ≤ 65 yards between March 1 – July 15 | ≤ 0.25 mile |
| Heavy equipment for logging, road construction, road repairs, bridge construction, culvert replacements, etc. | Not allowed ≤ 65 yards between March 1 – July 15 | ≤ 0.25 mile |
| Pile-driving (steel H piles, pipe piles); Rock Crushing and Screening Equipment | Not allowed ≤ 120 yards between March 1 – July 15 | ≤ 0.25 mile |
| Burning (prescribed fires, pile burning) | Not allowed ≤ 0.25 miles between March 1 – July 15 | ≤ 1 mile |
| Blasting | Not allowed ≤ 0.25 miles between March 1 – July 15 and not allowed ≤ 100 yards between July 16 - Sept. 30 | ≤ 1 mile |
| Helicopter: Chinook 47d | Not allowed ≤ 265 yards between March 1 – July 15 and not allowed ≤ 100 yards (hovering only) between July 16 - Sept. 30 | ≤ 0.5 mile |
| Helicopter: Boeing Vertol 107, Sikorsky S-64 (SkyCrane) | Not allowed ≤ 150 yards between March 1 – July 15 and not allowed ≤ 50 yards (hovering only) between July 16 - Sept. 30 | ≤ 0.25 mile |
| Helicopters: K-MAX, Bell 206 L4, Hughes 500 | Not allowed ≤ 110 yards between March 1 – July 15 and not allowed ≤ 50 yards (hovering only) between July 16 - Sept. 30 | ≤ 0.25 mile |
| Small fixed-wing aircraft (Cessna 185, etc.) | Not allowed ≤ 110 yards between March 1 – July 15 | ≤ 0.25 mile |

**Table B-2. Disturbance, disruption and/or physical injury distance thresholds for northern spotted owls (USDI FWS 2016b; Table 227, pp. 597-600).**

| Project Activity | No Effect | NLAA "may affect" disturbance distance | LAA early nesting season disruption distance (Mar 1–Jul 15) | LAA late nesting season disruption distance (Jul 16–Sep 30) | LAA direct injury and/or mortality (Mar 1 – Sep 30) |
|---|---|---|---|---|---|
| Light maintenance (*e.g.*, road brushing and grading) at campgrounds, administrative facilities, and heavily-used roads | >0.25 mile | ≤ 0.25 mile | NA[1] | NA | NA |
| Log hauling on heavily-used roads | >0.25 mile | ≤ 0.25 mile | NA[1] | NA | NA |
| Chainsaws (includes felling hazard/danger trees) | >0.25 mile - | 66 yards to 0.25 mile - | ≤ 65 yards[2] | NA | NA |
| Heavy equipment for road construction, road repairs, bridge construction, culvert replacements, etc. | >0.25 mile | 66 yards to 0.25 mile | ≤ 65 yards[2] | NA | NA |
| Pile-driving (steel H piles, pipe piles) Rock Crushing and Screening Equipment | >0.25 mile | 120 yards to 0.25 mile | ≤ 120 yards[3] | NA | ≤ 5 yards (injury)[3] |
| Blasting | >1 mile | 0.25 mile to1 mile | ≤ 0.25 mile[4] | NA | ≤ 100 yards (injury)[4] |
| Helicopter: Chinook 47d | >0.5 mile | 266 yards to 0.5 mile | ≤ 265 yards[5] | ≤ 100 yards[6] (hovering only) | NA |
| Helicopter: Boeing Vertol 107, Sikorsky S-64 (SkyCrane) | >0.25 mile | 151 yards to 0.25 mile | ≤ 150 yards[7] | ≤ 50 yards[6] (hovering only) | NA |
| Helicopters: K-MAX, Bell 206 L4, Hughes 500 | >0.25 mile | 111 yards to 0.25 mile | ≤ 110 yards[8] | ≤ 50 yards[6] (hovering only) | NA |
| Small fixed-wing aircraft (Cessna 185, etc.) | >0.25 mile | 111 yards to 0.25 mile | ≤ 110 yards | NA | NA |
| Tree Climbing | >66 yards | 26 yards to 65 yards | ≤ 25 yards[9] | NA | NA |
| Burning (prescribed fires, pile burning) | >1 mile | 0.25 mile to 1 mile | ≤ 0.25 mile[10] | NA | NA |

**NLAA** = "not likely to adversely affect." **LAA** = "likely to adversely affect" **≥ is greater than or equal to, ≤ is less than or equal to.**

**Table B-2 (Northern Spotted Owl) Footnotes:**

1. NA = not applicable. Based on information presented in Temple and Guttiérez (2003, pg. 700), Delaney *et al*. (1999, pg. 69), and Kerns and Allwardt (1992, pg. 9), we anticipate that spotted owls that select nest sites in close proximity to open roads either are undisturbed by or habituate to the normal range of sounds and activities associated with these roads.

2. Based on Delaney *et al*. (1999, pg. 67) which indicates that spotted owl flush responses to above-ambient equipment sound levels and associated activities are most likely to occur at a distance of 65 yards (60 meters) or less.
3. Impulsive sound associated with pile-driving is highly variable and potentially injurious at close distances. A reviewcompiled by Dooling and Popper (2007, pg. 25) indicates that birds exposed to multiple impulses (*e.g.*, pile driving) of sound at 125 decibels (dBA) or greater are likely to suffer hearing damage. We have conservatively chosen a distance threshold of 120 yards for impact pile-driving to avoid potential effects to hearing and to account for significant behavioral responses (*e.g.*, flushing) from exposure to loud, impulsive sounds. Based on an average maximum sound level of 110 dBA at 50 feet for pile-driving, exposure to injurious sound levels would only occur at extremely close distances (*e.g.*, ≤ 5 yards).
4. Impulsive sound associated with blasts is highly variable and potentially injurious at close distances. We selected a 0.25-mile radius around blast sites as a disruption distance based on observed prairie falcon flush responses to blasting noise at distances of 0.3 – 0.6 miles from blast sites (Holthuijzen *et al*. 1990, pg. 273). Exposure to peak sound levels that are >140 dBA are likely to cause injury in the form of hearing loss in birds (Dooling and Popper 2007, pgs. 23-24). We have conservatively selected 100 yards as an injury threshold distance based on sound levels from experimental blasts reported by Holthuijzen *et al*. (1990, pg. 272), which documented peak sound levels from small blasts at 138 – 146 dBA at a distance of 100 meters (110 yards).
5. Based on an estimated 92 dBA sound-contour (approximately 265 yards) from sound data for the Chinook 47d presented in Newman *et al*. (1984, Table D.1).
6. Rotor-wash from large helicopters is expected to be disruptive at any time during the nesting season due the potential for flying debris and shaking of trees located directly under a hovering helicopter. The hovering rotor-wash distance for the Chinook 47d is based on a 300-foot radius rotor-wash zone for large helicopters hovering at < 500 above ground level (from WCB 2005, pg. 2 – logging safety guidelines). We reduced the hovering helicopter rotor-wash zone to a 50-yard radius for all other helicopters based on the smaller rotor-span for all other ships.
7. Based on an estimated 92 dBA sound contour from sound data for the Boeing Vertol 107 the presented in the San Dimas Helicopter Logging Noise Report (USFS 2008, chapters 5, 6).
8. The estimated 92 dBA sound contours for these helicopters is less than 110 yards (*e.g.*, K-MAX (100 feet) (USFS 2008, chapters 5, 6), and Bell 206 (85-89 dBA at 100 meters) (Grubb *et al*. 2010, pg. 1277).
9. Based on Swarthout and Steidl (2001, pg. 312) who found that 95 percent of flush responses by spotted owls due to the presence of hikers on trails occurred within a distance of 24 meters.
10. Based on recommendations presented in *Smoke Effects to Northern Spotted Owls* (USDI FWS 2008, pg. 4).

## APPENDIX C. MONITORING FORM

**Consultation NSO/MAMU Effects Data Input Form (Revised 8/2017)**
**For use in preparing BA, BO, and annual tracking reports**

**Section I: Consultation Identifier Information (complete for each form)**

| Consultation Type | Consultation# | Consultation Name | | Sale Volume | |
|---|---|---|---|---|---|
| ○ Formal<br>○ Informal<br>○ Tech Assistance<br>○ Tech Asst Nat Event | | | | | |
| | Reinitiation Cross Ref | Consultation Author | | Fiscal Year Signed | |
| | | | | | |
| | ◯Suppl or ◯Replace | Termination Date | / / / | Signature Date | / / / |
| Comments | | | | | |

**Section II: Ownership and Location Identifier Information[1]**

| Species | Physiographic Province | Group | Land Use Allocation | CHU Identifier |
|---|---|---|---|---|
| | | ○ NWFP Lands<br>○ W. OR RMP<br>○ Tribal<br>○ Other Fed Agency<br>○ HCP<br>○ Other Pvt/State | ○ LSR<br>○ Matrix<br>○ Adaptive Mgmt Area<br>○ Harvest Land Base<br>○ East Side Mgmt Area<br>○ Other Reserve (i.e.RR) | |
| Agency | MAMU Conserv. Zone | | | Decade |
| | | | | |
| Administrative Unit | Timber Sale? | | | |
| | ◯ Yes ◯ No | | | |
| | Report Type | | | |
| Administrative Subunit | ◯Authorized<br>◯Not Implemented | MAMU Conservation Zone | LUA Identifier # | |
| | Project Report Name | | | |
| | | | | |

**Section III: NSO Consultation Habitat Effects (requires separate form for each change in any data entry field in Sec. II.**

| Affected Suitable Habitat | | | | Habitat Associated Take | | | Dispersal Habitat (non-NRF) | |
|---|---|---|---|---|---|---|---|---|
| Effect | NRF | NR | F | Acres | ACs w acres | ACs w/o acres | Acres | Assoc Harm |
| Removed | | | | | | | | |
| Downgraded | | | | | | | | |
| Treat/Maintain | | | | | | | | |
| Improved | | | | | | | | |
| Added | | | | | | | | |
| ◯ Harm | Disturbance/Disruption Effects | | | FY | FY | FY | FY | FY |
| | Acres (w/o LOPs) | | | | | | | |
| ◯Harass | # of Activity Centers (w/ acres) | | | | | | | |
| | # of Activity Centers (w/o acres) | | | | | | | |

**Section III. MAMU Consultation Habitat Effects (requires separate form for each change in any data entry field in Sec. II.**

| Affected Suitable Habitat | | | | | Nesting Habitat Associated Harm (subset of affected suitable habitat) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Effect (acres) | Stands | Remnants | Acres CHU ½ site Potential w/in 0.5 mile of potential nest tree (PCE2)[2] | Suveyed Not Occupied[3] | Unsurveyed Acres | | Occupied Acres | | |
| Removed | | | | | | | | | |
| Treat/Maintain | | | | | | | | | |
| Degraded | | | | | | | | | |
| Added | | | | | | | | | |
| # of Trees | | | | | | | | | |
| ◯ Harm | Disruption Effects (non-hab) | | | | Annual Effects (By Fiscal Year) | | | | |
| | Unsurveyed Suitable Acres | | | | FY | FY | FY | FY | FY |

| | | | | | | |
|---|---|---|---|---|---|---|
| ◯**Harass** | **Occupied Suitable Acres** | | | | | |
| | **# of Individuals** | | | | | |
| **Sections II and III: General Notes and Comments** | | | | | | |

**Administration Unit –** National Forest or BLM Administrative District or National Park
**Administrative Subunit –** USFS Ranger District or BLM Resource Area
**Tech Asst Nat Event =** Check if reporting effects of a natural event (i.e. wildfire)
**Footnotes**
[1]Requires separate data entry form for each change in any field (i.e. for matrix treatments and LSR treatments).
[2] **PCE 2 =** forested areas within 0.5 mile (0.8 kilometer) of individual trees with potential nesting platforms, and with a canopy height of at least one-half the site-potential tree height. Enter as separate data sheet if only portion of action is within CH.
[3] **Surveyed Not Occupied**

**APPENDIX D: Spotted Owls, Ecological Forestry and Efficacy of Forest Treatments**

This Resilient Lands Consultation relies on the use of best available information when addressing wide-ranging species such as the spotted owl, its habitat associations and effects of habitat management. However, the information available rarely addresses all of the questions at hand, meaning there remains some degree of uncertainty. Hence, there is inherently an element of risk management (especially for wide-ranging species which face a multitude of threats) because habitat management recommendations made either by the Service or BLM and resulting management decisions face incomplete information and uncertainty.

The Service's Revised Northern Spotted Owl Recovery Plan (USDI FWS 2011) reviewed the best available information, weighed the uncertainty and provided restoration principles and discretionary recovery actions to address the threat from habitat loss due to large-scale wildfire in the dry forest ecosystems. The Recovery Plan advised that based on best available information and despite uncertainty, strategic active forest management was a prudent and proactive approach to follow in the dry forests. The BLM (USDI BLM 2016) utilized the Recovery Plan and also weighed the contemporary science and developed a resource management plan based in active forest management. Active forest management strategies to address the threat from habitat loss is an expression of risk and resulting actions, and may not match the risk tolerance of every interested party. However, it is the conclusion of the Service's Revised Recovery Plan and other best available information (as provided below) that strategic actions are necessary to achieve the Plan's goal for the conservation and survival of the species (USDI FWS 2011, p. II-6).

Underlying active management and species recovery under the Revised Recovery Plan is the stated purpose of the ESA: "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." Consistent with this purpose, it is the Service's goal that this spotted owl recovery strategy be embedded within -- and be consistent with -- a broader framework of conservation of forest ecosystems for the Pacific Northwest. This approach will provide more resilient forested habitat in the face of climate change and other stressors, thereby conserving more spotted owl habitat on the landscape for longer periods of time. Species-specific needs of the spotted owl should not be the sole determinant of landscape management decisions. Rather, spotted owl recovery objectives should fit within a broader strategy whose goals include the conservation of the full assemblage of species and ecological processes in that landscape so that it will be more resilient to future losses of spotted owl habitat or ecosystem change resulting from climate change and other disturbances (USDI FWS 2019).

On western Oregon BLM lands, the broader forest management strategy is the BLM's 2016 RMP and on Forest Service lands, is the Northwest Forest Plan (USDA and USDI 1994). These Forest Plans provide for spotted owl recovery and benefit many other late-successional forest species (USDI FWS 2011, p. 11 and 12 and USDI FWS 2016 pgs 426, 620 and 782). However, there have been several significant developments that affect spotted owl recovery during the life of these plans, and include: continued decline of spotted owl populations, low occupancy rates in large habitat blocks, negative impacts from barred owls, climate change, and scientific principles continue to evolve on forest management (see Lesmeister et al 2018, entire). Because of these factors, spotted owl management is likely best informed by implementing decisions within a broader landscape approach based on the conservation of natural ecological patterns and processes (see below), as articulated in the management plans.

These issues are not mutually exclusive, and spotted owl recovery depends on the integration of all facets to the degree possible. Extant, high-quality spotted owl habitat must be managed, restored, and conserved in the face of a declining population and the potential threats from barred owls. Active, restoration-focused management to address climate change and dynamic ecosystem processes is also necessary in many areas, with the goal of maintaining or restoring forest ecosystem structure, composition and processes so they are sustainable and resilient under current and future climate conditions (USDI FWS 2011, II-11).

As mentioned above, there is a strong scientific consensus that Pacific Northwest forests, including the dry forests in southwest Oregon, are already undergoing significant changes from current conditions due to past management practices, shifting disturbance patterns, and changing climate influences. There is a variety of scientific opinion regarding the extent to which land managers can manage or positively influence these changes (Millar et al. 2007, Reinhardt et al. 2008), and how such shifts may affect spotted owls (see, e.g., Hanson et al. 2009, 2010 and Spies et al. 2010b). To address this uncertainty, "active forest management" has been proposed as an approach that includes "ecological forestry and restoration" as described by Franklin et al. (2007), Carey (2007), Johnson and Franklin (2009), Long (2009), and Spies et al. (2010a), among others. Forest restoration should be applied where the best available science suggests ecosystems and spotted owls would benefit in the long-term. In many cases, it is evident that some forest areas need or would benefit from restoration treatments, whereas others are at less risk or the science is less clear about how to treat certain areas. Forest managers and policy makers must take reasonable but proactive steps to conserve forest ecosystems and spotted owls in the face of past management and future uncertainty (Agee 2002, Carey 2007, Gaines et al. 2010); and there is a scientific and social consensus emerging that land managers must restore more sustainable (resistant and resilient) ecological processes to forests at various landscape scales (Hessburg et al. 2004, Millar et al. 2007, Long 2009, Moritz et al. 2011).

Retrospective studies and emerging work suggests that fuel reduction treatments, including treatments as proposed in this Resilient Lands consultation, modify subsequent fire behavior, reducing the likelihood of high intensity fire with high mortality (Fulé et al. 2012, Safford et al. 2012, Martinson and Omi 2013, Yocom Kent et al. 2015, Lydersen et al. 2017, Prichard et al. 2020). To be most effective, a combination of methods, when used in concert, reduce fire spread. These methods include mechanical treatments with follow-up prescribed burning. Mechanical treatments that reduce fuels can still mitigate potential wildfire behavior but to a much lesser extent than those that include burning (Stephens et al. 2009, Martinson and Omi 2013, Lydersen et al. 2017, Prichard et al. 2020). Prescribed burning is critical for reducing fuels (Finney et al. 2005, Stephens et al. 2009, Prichard et al. 2010, Martinson and Omi 2013, Prichard and Kennedy 2014, Lydersen et al. 2017, Prichard et al. 2020). Fuel treatments in advance of wildfire can increase forest resistance and resilience, even in the case of mega-fire (Shive et al. 2013, Stevens-Rumann et al. 2013, Lydersen et al. 2014, Prichard and Kennedy 2014, Lydersen et al. 2017, Tubbesing et al. 2019, Prichard et al. 2020).

Given wildfire threats to complex old forest, including the same type of forests being conserved in the Resilient Lands action area, fuel treatments may actually be necessary to protect late successional habitat from the effects of uncharacteristically severe fire (Spies et al. 2006, Kennedy and Wimberly 2009, Ager et al. 2010, Gaines et al. 2010, Roloff et al. 2012, Jones et al. 2016, Lesmeister et al. 2019), though short-term costs need to be weighed against long-term benefits (Tempel et al. 2015, Lesmeister et al. 2018).

Even though treatments are reasonably certain to modify subsequent fire behavior (based on the authors conclusions above), questions remain about the costs and impacts of fuel treatments including impacts to spotted owls as described in this consultation) given the probability that an individual treated unit will experience fire within the effective lifespan of that treatment (Schoennagel et al. 2004, Campbell et al. 2011, Barnett et al. 2016, Schoennagel et al. 2017, Barros et al. 2019). Much has been learned about optimal treatment placement and fire behavior models, and historical burn patterns are increasingly facilitating the effective placement of treatments (e.g., Stevens et al. 2016, Vaillant and Reinhardt 2017, Barros et al. 2019, Tubbesing et al. 2019, Roloff et al. 2012).

Consideration of fuel treatment effectiveness, probability of encountering wildfire, and economics all are inherently dependent on spatial and temporal scale. Fuel treatments implemented under forest restoration principles have over-arching co-benefits including forest resiliency and maintaining old fire-resistant trees. Restorative fuel treatments are designed at a landscape scale and intended for maintenance over time, so economics and effectiveness also need to consider larger spatial and temporal scales whereby the probability that treatments will interact with wildfire is high. These forest restoration principles are given consideration and PDCs are applied under this Resilient Lands consultation.

One of the primary objectives of the resiliency restoration treatments within the Resilient Lands action area are to incrementally improve forest resiliency and reduce large scale fire risk. When a larger area of the landscape is in restored condition, fire suppression effectiveness and safety are improved, enabling more options for managed fire to achieve more economical outcomes and restoration of a more natural fire regime (e.g., Kennedy and Johnson 2014, Thompson et al. 2016a,b). Over time and with a higher proportion of the action area landscape in a condition that reduces large scale fire risk and increases the persistence of old forest habitat, the treated areas are expected to influence fire. For example, even with the Rim Megafire, a smaller proportion of treated area (10-40 percent) was sufficient to diminish the proportion of high severity fire (Lydersen et al. 2017). This clarifies the common narrative that individual treatment units can be overwhelmed by fire weather (e.g., hot, dry, windy, low humidity conditions), but that in aggregate across a landscape, treatments significantly influence burn outcomes.

There is however, competing science, and hence the uncertainty that is described above. For example, DellaSalla and Hanson (2019) detected a significant increase in the total area of large patches relative to the first time period of study (1984–1991), but no significant upward trend since the early 1990s. Meaning that there was no significant trend in the size of large complex early seral forest patches between 1984 and 2015. The authors go on to counter claims used by some researchers and decision-makers to justify large-scale forest "thinning" and post-fire logging projects—specifically, the assumption that such logging projects are needed to prevent type conversion in response to a perceived increase in early seral patch sizes and conifer regeneration failures in "megafires" (see Stevens et al. 2016, Stephens et al. 2013, Hessberg et al. 2015, and Hessberg et al. 2016). DellaSalla and Hanson recommend that land managers focus limited resources on community fire safety and defensible space of homes as a means of getting to coexistence with wildfire [see Cohen 2000, Moritz et al. 2014 and Schoennagel 2017] and for managing wildfire under safe conditions for a myriad of ecosystem benefits. Further, there is an ongoing debate, as captured in Hanson et al. (2009, 2010) and Spies et al. (2010b), regarding the relative merits of active management in dry forest landscapes and the potential positive and negative impacts to spotted owls (Spies et al. 2006). This debate focuses on uncertainty and

seems to be one of degree rather than fundamental difference in long-term conservation goals. Land managers, such as the BLM Districts in this consultation, are attempting to implement a program of landscape-scale, science-based adaptive restoration treatments in disturbance prone forests that will reconcile the goals of conserving and encouraging spotted owl habitat while better enabling forests to: (1) recover from past management measures, and (2) increase forest resiliency (Spies et al. 2006, 2010a,b, Millar et al. 2007, Reinhardt et al. 2008, Haugo et al. 2010, Keane et al. 2009, North et al. 2010, Littell et al. 2010, Stephens et al. 2010). Using this restorative approach, it is anticipated that more high quality spotted owl habitat will be provided relatively sooner and for a longer duration into the future which will greatly benefit spotted owl recovery in the long-term. For the dry forests of the Rogue Basin, which covers a very large portion of the Resilient Lands action area, the Rogue Basin Comprehensive Strategy (Metlen et al. 2017) provides an approach for how to consider reconciling spotted owl habitat management with vegetation management. Some of the principles in that Strategy are incorporated into this Resilient Lands proposed action.

The concept of "conservation of ecological processes" has long been an underlying principle of "ecosystem management" and is familiar to most land managers in the Pacific Northwest. Ricklefs et al. (1984) proposed this concept to include basic ecological cycles on large landscapes, such as the soil formation cycle and the hydrological cycle, with the understanding that fish and wildlife resources are integral to these cycles. That is, conserve the ecological processes and you conserve fish and wildlife. Natural disturbance processes – wildfire, disease, insect outbreaks and windthrow – are important forces that influence spotted owl habitat. The scientific study and emulation of these processes has emerged as a "dominant paradigm in North American forest management" (Long 2009).

A good synopsis of disturbance-based management for forested systems is provided by North and Keeton (2008:366): "Disturbance-based forest management is a conceptual approach where the central premise might be summarized as 'manipulation of forest ecosystems should work within the limits established by natural disturbance patterns prior to extensive human alteration of the landscape' (Seymour and Hunter 1999). Although such an objective seems like a simple extension of traditional silviculture, it fundamentally differs from past fine-filter approaches that have manipulated forests for specific objectives such as timber production, water yield, or endangered species habitat. Some critics have argued that this approach leaves managers without clear guidelines because the scale and processes of ecosystems are poorly defined, making it difficult to directly emulate the ecological effects of natural disturbances (USDI FWS 2011, III-13). Under the Revised Recovery Plan, the Service continues to recommend that active forest management and disturbance-based principles be applied throughout the range of the spotted owl with the goal of maintaining or restoring forest ecosystem structure, composition and processes so they are sustainable and resilient under current and future climate conditions in order to provide for long-term conservation of the species. The majority of published studies support this general approach for Pacific Northwest forests, although there is some disagreement regarding how best to achieve it. Most of this variance in opinion is due to the scientific uncertainty in: (1) accurately describing the ecological "reference condition" or the "natural range of variability" in historical ecological processes, such as fire and insect outbreaks across the varied forest landscape within the range of the spotted owl (e.g., see Hessburg et al. 2005, and Keane et al. 2002, 2009); and (2) confidently predicting future ecological outcomes on this landscape due to rapid, climate-driven changes in these natural processes, with little precedent in the historical (or prehistoric) record (Drever et al. 2006, Millar et al. 2007, Long 2009, Littell et al. 2010). Again, the goal is not to restore forests to a particular time period pre-fire exclusion. Rather the

restoration goal is to implement forest practices that emulate disturbance processes and provide for ecosystem function and processes to take hold.

In summary, from the best available science, there is ample evidence that fuel treatments are effective at mitigating wildfire effects in forests and at giving fire suppression personnel increased options and safety for managing wildfires. If strategically applied, the restoration activities covered under this Resilient Lands consultation would provide for spotted owl habitat over the long-term by conserving the ecosystem upon which the species relies. This approach, while controversial, is a land management perspective that is embraced by most forest ecologists and biologists and is well published in the scientific literature. Given the competing threats to the spotted owl, embedding spotted owl recovery into the management of large landscapes is likely the most reasonable and likely successful approach to restoring habitat and recovering spotted owls. A recovery strategy and land management plans requires action in the face of uncertainty. As Carey (2007, pg. 345, 349) has indicated: "(A)ctive management for ecological values trades short-term negative effects for long-term gains. Collaborative management must be willing to accept short-term impacts and short-term risks to achieve long-term benefits and long-term risk reduction; overly zealous application of the precautionary principle often is a deliberate, conscious management decision to forego long-term increases in forest health and resilience to avoid short-term responsibility or controversy." In other words, land managers should not be so conservative that, to avoid risk, they forego actions that are necessary to conserve the forest ecosystems that are necessary to the long-term conservation of the spotted owl (USDI FWS 2011). However, managers should not be so aggressive that they subject spotted owls and their habitat to treatments where the long-term benefits do not clearly outweigh the short-term risks. Finding the appropriate balance to this dichotomy will remain an ongoing challenge for all who are engaged in spotted owl conservation. Federal land, such as BLM lands with dry forests across southwest Oregon and further subject to this Resilient Lands consultation, will undergo section 7 consultation to assess the impact to the spotted owl.

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# EXHIBIT B

To: Acting Assistant Regional Director, Ecological Services, Interior Regions 9/12, Portland, Oregon

From: State Supervisor, Oregon Fish and Wildlife Office
Portland, Oregon PAUL HENSON Digitally signed by PAUL HENSON Date: 2021.01.15 15:07:24 -08'00'

Subject: Response to January 7, 2021, Memorandum, "Extinction Analysis for the Northern Spotted Owl," from Director Skipwith to Secretary Bernhardt

On January 14, 2021, I was provided a copy of the January 7, 2021, memorandum entitled "Extinction Analysis for the Northern Spotted Owl," from Director Skipwith to Secretary Bernhardt (Memo). The stated purpose of this Memo was for the Director to present to the Secretary her analysis of whether recommended exclusions of critical habitat (CH) would result in extinction of the northern spotted owl (NSO).

The purpose of this memorandum to you is to clarify and correct some potential misinterpretations of the scientific information and conclusions in the Director's memo. Information and communications provided by my staff and me to the Director were cited in the Memo, and I would like to use this opportunity to ensure that this information is correctly interpreted from a scientific perspective.

In a December 9, 2020, email to the Director and other Department leadership cited in the Memo, I provided my scientific recommendation concerning the potential critical habitat exclusions being considered at that time by the Department:

> "Lastly, I feel a duty as the NSO recovery lead for the Service to reiterate here what I described in the three recent meetings with DOI leadership. If DOI excludes the large amount of critical habitat requested by the commenters, including the federal O&C reserve lands, and this exclusion leads to subsequent habitat management on these lands that is inconsistent with the current BLM and FS land management plans, it is my opinion it will preclude the recovery of the NSO. Most scientists (myself included) would conclude that such an outcome will, therefore, result in the eventual extinction of the listed subspecies. No one can give a precise timeframe for when this would occur, but it is a reasonable scientific conclusion."

The Director and the Department subsequently arrived at a decision to exclude 3,472,064 acres of critical habitat from the total of 9,577,342 acres designated as critical habitat for NSO in 2012, or 36% of the total. Most of this exclusion is concentrated in Oregon and, due to its geographic location and habitat quality, it represents a significant portion of the NSO's most important remaining habitat. The Director's memo provides seven separate justifications for why an exclusion of this magnitude will not result in the extinction of

the species, as required under section 4(b)(2) of the Endangered Species Act (Act). Below I provide clarification or additional scientific perspective on each of these points.

1. *Section 9 ESA protections will ensure the NSO is not jeopardized even if CH is removed.*
   These section 9 protections only legally apply to habitat areas with extant spotted owls and/or where site-specific surveys show owls are currently present and proposed actions might take these individuals. As stated in the 2011Recovery Plan, "It is not uncommon for an occupied spotted owl site to be unoccupied in subsequent years, only to be re-occupied by the same or different spotted owls two, three or even more years later (Dugger et al. 2009). While temporarily unoccupied, these sites provide conservation value to the species by providing habitat that can be used by spotted owls on nearby sites while also providing viable locations on which future pairs or territorial singles can establish territories." The CH includes multiple such areas. Thus, section 9 prohibitions will only protect a subset of the excluded CH areas where NSO have not been displaced.

2. *The plain language of the Act says the Secretary cannot exclude CH from a designation if such exclusion "will" result in extinction, and it is "speculative at best" to suggest these exclusions will result in extinction of the NSO.*
   The best scientific information strongly suggests that the NSO population is in a precipitous decline, and the Service recently concluded that the NSO warranted uplisting to endangered status under the Act. The subspecies is essentially extinct in British Columbia, rapidly declining to near extirpation in Washington and parts of Oregon, and in the earlier stages of similar declines in the rest of its range. As the statutory definition of "endangered" states, the NSO is in very real "danger of extinction throughout all or a significant portion of its range." The Director's statement, "yet the NSO population continues to persist," seems to suggest the NSO population will *continue* to persist into the foreseeable future. The science simply does not support this suggestion (see below). Significant changes to habitat conservation will exacerbate this decline by working synergistically with the impacts from barred owl.

3. *The NSO population modeling from the 2011 Revised Recovery Plan suggests that NSO will not go extinct if a barred owl eradication program is put in place.*
   Not surprisingly, models and the barred owl removal experiment do suggest that NSO recovery chances improve significantly if an effective barred owl management program is put in place and maintained. However, it is premature to conclude that such a program will be put in place and that it will be effective. There are tremendous economic, logistical, social, and legal obstacles that need to be overcome first. The Service is working hard toward this goal, but at this point in the process it is speculative at best that this outcome will be achieved. Also, it must be noted that the impact of barred owls on NSO has made the conservation of extant habitat even more pressing, at least in the near term until a barred owl management plan is in place and shown to be effective. The CH exclusions work

at cross-purposes with this need.

Also, the NSO Recovery Plan modeling scenarios all assumed that these CH areas in reserves would be protected from harvest; it did not model a scenario with these areas being harvested, with or without barred owl management occurring.

4. *NSO use logged habitat.*
   This statement is accurate, but it must be put in context. Logged areas (depending on the treatment) are usually much lower quality for NSO than are older, more complex forests, and NSO survival and reproduction rates are likewise lower in such lower quality areas. It is inaccurate to suggest that NSO populations are sustainable in such areas without proximal access to higher quality habitat areas, or that such areas provide some sort of fundamental component of a NSO conservation strategy.

5. *"To the extent the Field office director is suggesting that exclusion from critical habitat will lead to immediate and drastic change in management across the excluded portion, history shows that result is very unlikely."*
   This statement is not an accurate characterization of my email; I did not suggest there would be an immediate and drastic change in management. The Director's memo suggests as a consequence of this CH exclusion that "any increased logging will be incremental and will take place over time," and therefore extinction of NSO will be avoided because some owls can persist as these areas are slowly harvested in the future. Historic harvest rates of these areas under the Northwest Forest Plan are cited to justify this conclusion of a relatively slow harvest timeframe. It is important to note that these historic harvest rates were themselves influenced by critical habitat designations of these lands as well as other policies, and future harvest rates would not, in all likelihood, reflect past harvest rates if this CH exclusion leads to changes in land management goals. In fact, in previous meetings with Service staff, DOI leadership has suggested that harvest rates on the Oregon Bureau of Land Management CH lands should increase 4-5 fold from these historic rates (i.e., from @200mmbf to 1 billion mmbf). Likewise, such increases are a specific goal of the timber industry commenters and plaintiffs to whom these CH exclusions are responsive. It is important to note that such elevated harvest rates, which did occur on BLM lands during the period after World War II until the 1980's, created the very conditions that led to the listing of the NSO. Therefore, my concern about the potential impacts of future harvest on NSO populations cited in the Director's memo is not misplaced and is probably the more likely outcome of the exclusions.

6. *"There is a significant amount of protected habitat located in National Parks and wilderness that will never be logged and is used by the NSO…Absent invasions by the barred owl or wildfire, this habitat and the owls living therein will be maintained in their current state regardless of any critical habitat exclusions."*
   It is accurate to state that there are NSO existing in Congressional-reserved areas outside of critical habitat, such as National Parks and some lower elevation and

forested wilderness. However, it is mistaken to suggest NSO are not at risk in these areas "absent invasions by barred owl or wildfire," as if these areas are either immune to or are not already experiencing such invasions. NSO populations have been declining in such Congressionally-reserved areas for years due to the impacts associated with barred owls and wildfire. Although these areas do provide some refugia for NSO from direct human impacts (i.e., timber harvest), they cannot be relied upon to provide sustainable populations of NSO into the future unless they are part of and connected to a wider reserve network.

7. *The demographic population monitoring and modeling process (Dugger et al. 2016) for the NSO "leads to results that are too conservative and may undercount the species… Although this appears to be the 'best commercial and scientific data available' for making population estimates, it is imprecise at best in determining if the habitat exclusions proposed 'will result' in extinction of the species."*
As of this writing I do not have all the information that the Director used to question the accuracy of the federal agencies' NSO demographic modeling process, but it is worth noting that the results of this ongoing program have been regularly published every five years in prestigious peer-reviewed scientific journals. Regardless, the Director's memo seems to misunderstand how the Service uses the demographic data to inform decisions regarding NSO. Most importantly, this data gives accurate (if not precise) insight into the status and trend of the NSO population. This in turn informs land management decisions that might affect NSO at various scales, including that of the rangewide critical habitat designation. The model results are relevant and useful in assessing the potential adverse impacts of a massive CH exclusion to the NSO population.

Put simply, the justification for the conclusion made in my December 9, 2020, email to the Director is: (1) NSO populations are declining precipitously due to a combination of historic habitat loss and more recent competition with the barred owl; and (2) the only way to arrest this decline and have a high probability of preventing extinction (in any timeframe) is to manage the barred owl threat and conserve adequate amounts of high quality habitat distributed across the range in a pattern that provides acceptable levels of connectivity as well as protection from stochastic events. The 2012 critical habitat designation met the habitat conservation portion of this goal. The proposed CH exclusion, given its disproportionate concentration in high quality habitat in Oregon, thwarts this goal.

Assuming the excluded CH areas are harvested to the levels desired by the commenters for whom this exclusion is being made (see above), it is reasonable to conclude that it will result in the extinction of the NSO. The Director's memo suggests that the plain language of the Act – "will result in extinction" -- means this outcome must not be speculative or occur some (unspecified) distance out into the future. I generally defer to DOI solicitors' interpretation of the legal meaning of statutory language, but from a scientific perspective I will suggest that such a narrow interpretation renders this aspect of the Act irrelevant for most listed species. Such a high standard of certitude and immediacy would only apply to the rarest, most narrowly distributed, and most critically

endangered of species. For the NSO and most other species, a more appropriate biological definition of the 4(b)(2) language ("will result") would be "more likely than not" or "has a high likelihood" to result in the extinction of the species. The NSO CH exclusions clearly meet this threshold.

# EXHIBIT C

U.S. Fish & Wildlife Service

# Revised Recovery Plan for the Northern Spotted Owl (*Strix occidentalis caurina*)

Cover photo:

# Revised Recovery Plan for the Northern Spotted Owl (*Strix occidentalis caurina*)

Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: Robyn Thorson
Regional Director, U.S. Fish and Wildlife Service

Date: JUN 2 8 2011

## Disclaimer

Recovery plans describe reasonable actions and criteria that are considered necessary to recover listed species. Recovery plans are approved and published by the U.S. Fish and Wildlife Service ("Service" or "we" in narrative, (except as otherwise indicated) "USFWS" in citations, "FWS" in tables) and are sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others. The 2011 Revised Recovery Plan for the Northern Spotted Owl (Revised Recovery Plan) does not necessarily represent the view or official position of any individual or organization—other than that of the Service—involved in its development. Although the northern spotted owl is a subspecies of spotted owl, we sometimes refer to it as a species when discussing it in the context of the ESA or other laws and regulations.

Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions. The objectives in this Revised Recovery Plan will be achieved subject to availability of funding and the capability of the involved parties to participate while addressing other priorities. This Revised Recovery Plan replaces, in its entirety, the 2008 Recovery Plan.

## Notice of Copyrighted Material



## Citation

U.S. Fish and Wildlife Service. 2011. Revised Recovery Plan for the Northern Spotted Owl (*Strix occidentalis caurina*). U.S. Fish and Wildlife Service, Portland, Oregon. xvi + 258 pp.

## Electronic Copy

A copy of the Revised Recovery Plan and other related materials can be found at: http://www.fws.gov/species/nso.

## Acknowledgments

The Service gratefully acknowledges the effort and commitment of the many individuals involved in the conservation and recovery of the northern spotted owl who participated in the preparation of both the 2008 Recovery Plan and this Revised Recovery Plan. Without their individual expertise and support, this Revised Recovery Plan would not have been possible as it is the culmination of many years of labor. This Revised Recovery Plan is the culmination of many hours of discussion, research and analysis by a large number of scientific experts and managers over several years.

This revision to the 2008 Recovery Plan has been led by the Service and builds upon the efforts of numerous individuals from several different agencies, academia, State governments and private organizations; their names and affiliations are listed in Appendix H. The Service is indebted to all of these individuals for the information provided during the preparation of this Revised Recovery Plan. Their names, affiliations, and roles are listed below. Their participation in the revision process does not imply these contributors or their sponsoring agencies agree with the recommendations and conclusions of this Revised Recovery Plan.

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# EXECUTIVE SUMMARY

## Current Status

The northern spotted owl (*Strix occidentalis caurina*) (spotted owl) inhabits structurally complex forests from southwest British Columbia through the Cascade Mountains and coastal ranges in Washington, Oregon, and California, as far south as Marin County (Appendix A). After a status review (USFWS 1990a), the spotted owl was listed under the Endangered Species Act (ESA) as threatened on June 26, 1990 (USFWS 1990b) because of widespread loss of spotted owl habitat across the spotted owl's range and the inadequacy of existing regulatory mechanisms to conserve the spotted owl. Past habitat loss and current habitat loss are also threats to the spotted owl, even though loss of habitat due to timber harvest has been greatly reduced on Federal lands over the past two decades. Many populations of spotted owls continue to decline, especially in the northern parts of the subspecies' range, even with extensive maintenance and restoration of spotted owl habitat in recent years. Managing sufficient habitat for the spotted owl now and into the future is important for its recovery. However, it is becoming more evident that securing habitat alone will not recover the spotted owl. Based on the best available scientific information, competition from the barred owl (*S. varia*) poses a significant and complex threat to the spotted owl.

**Based on the best available scientific information, competition from the barred owl (*S. varia*) poses a significant threat to the spotted owl.**

## Habitat Requirements

Scientific research and monitoring indicate spotted owls generally rely on mature and old-growth forests because these habitats contain the structures and characteristics required for nesting, roosting, and foraging. Although spotted owls can disperse through highly fragmented forested areas, the stand-level and landscape-level attributes of forests needed to facilitate successful dispersal have not been thoroughly evaluated or described.

## Delisting

In order to consider a species recovered, analysis of five listing factors must be conducted and the threats from those factors reduced or eliminated. The five listing factors are:

A. The present or threatened destruction, modification, or curtailment of the species' habitat or range;
B. Overutilization for commercial, scientific, or educational purposes;
C. Disease or predation;
D. Inadequacy of existing regulatory mechanisms;
E. Other natural or manmade factors affecting its continued existence.

## Recovery Strategy

Currently, the most important range-wide threats to the spotted owl are competition with barred owls, ongoing loss of spotted owl habitat as a result of timber harvest, habitat loss or degradation from stand replacing wildfire and other disturbances, and loss of amount and distribution of spotted owl habitat as a result of past activities and disturbances. To address these threats, this recovery strategy includes four basic steps:

1. Completion of a rangewide habitat modeling tool;
2. Habitat conservation and active forest restoration;
3. Barred owl management; and
4. Research and monitoring.

**In addition to describing specific actions to address the barred owl threat, this Revised Recovery Plan continues to recognize the importance of maintaining habitat for the recovery and long-term survival of the spotted owl.**

The U.S. Fish and Wildlife Service (Service) recognizes the barred owl constitutes a significantly greater threat to spotted owl recovery than was envisioned when the spotted owl was listed in 1990. As a result, the Service recommended in the 2008 Recovery Plan that specific actions to address the barred owl threat begin immediately. These actions are currently underway, and this Revised Recovery Plan builds on these actions.

In addition to describing specific actions to address the barred owl threat, this Revised Recovery Plan continues to recognize the importance of maintaining and restoring high value habitat for the recovery and long-term survival of the spotted owl.

Maintaining and restoring sufficient habitat is important to address the threats the spotted owl faces from a loss of habitat due to harvest, loss or alteration of habitat from stand replacing fire, loss of genetic diversity, and barred owls (Forsman *et al.* 2011). The 2008 Recovery Plan established a network of Managed Owl Conservation Areas (MOCAs) across the range of the species. Based on

scientific peer review comments the Service is not incorporating the previously recommended MOCA network into this Revised Recovery Plan. We will update spotted owl critical habitat; in the interim, we recommend land managers continue to implement the standards and guidelines of the Northwest Forest Plan (NWFP) throughout the range of the species, as well as fully consider other recommendations in this Revised Recovery Plan. We also support the updating of existing land management plans.

The estimated time to delist the species is 30 years if all actions are implemented and effective. While the 2008 Recovery Plan identified an interim 10-year timeframe, this revision identifies several actions that will take many years to implement effectively. Therefore, the Service believes that this Revised Recovery Plan can be fully implemented in a 30-year timeframe. A longer time to delisting would be required if these assumptions are not met. Total cost for delisting over these 30 years is $127.1 million (see Section IV; Implementation Schedule and Cost Estimates for specific costs).

Due to the uncertainties associated with the effects of barred owl interactions with the spotted owl and habitat changes that may occur as a result of climate change, the Service intends to implement this Revised Recovery Plan aggressively and will use the 5-year review process to evaluate recovery implementation and success. The Service and other implementers of this Revised Recovery Plan will have to employ an active adaptive management strategy to achieve results and focus on the most important actions for recovery. Adaptive management is a systematic approach for improving resource management by learning from the results of explicit management policies and practices and applying that learning to future management decisions.

After the 2008 Recovery Plan was finalized, an inter-organizational Northern Spotted Owl Recovery Plan implementation structure was established that included multiple interagency recovery implementation teams. This implementation structure will be reevaluated and updated in accordance with this Revised Recovery Plan.

## Recovery Goal

The goal of every Recovery Plan is to improve the status of the species so it can be removed from protection under the ESA. The long-term goal for the spotted owl is the same.

## Recovery Objectives

The objectives of this Revised Recovery Plan are:

1. Spotted owl populations are sufficiently large and distributed such that the species no longer requires listing under the ESA;
2. Adequate habitat is available for spotted owls and will continue to exist to allow the species to persist without the protection of the ESA; and
3. The effects of threats have been reduced or eliminated such that spotted owl populations are stable or increasing and spotted owls are unlikely to become threatened again in the foreseeable future.

## Recovery Criteria

There are four Recovery Criteria in this Revised Recovery Plan. Recovery Criteria are measurable, achievable goals that we believe will result from implementation of the recovery actions in this Revised Recovery Plan. Achievement of these criteria will take time and is intended to be measured over the life of the plan, not on a short-term basis and should not be considered near-term recommendations. Not all recovery actions necessarily need to be implemented for the Service to consider initiating the delisting process based on the statutory criteria for determining whether a species should be listed (16 U.S.C. § 1533(a)(1)).

**Recovery Criterion 1 – Stable Population Trend:** The overall population trend of spotted owls throughout the range is stable or increasing over 10 years, as measured by a statistically reliable monitoring effort.

**Recovery Criterion 2 – Adequate Population Distribution:** Spotted owl subpopulations within each province (*i.e.*, recovery unit) (excluding the Willamette Valley Province) achieve viability, as informed by the HexSim population model or some other appropriate quantitative measure.

**Recovery Criterion 3 – Continued Maintenance and Recruitment of Spotted Owl Habitat:** The future range-wide trend in spotted owl nesting/roosting and foraging habitat is stable or increasing throughout the range, from the date of Revised Recovery Plan approval, as measured by effectiveness monitoring efforts or other reliable habitat monitoring programs.

**Recovery Criterion 4 – Post-delisting Monitoring:** To monitor the continued stability of the recovered spotted owl, a post-delisting monitoring plan has been developed and is ready for implementation within the States of Washington, Oregon, and California, as required in section 4(g)(1) of the ESA.

## Recovery Actions

Recovery actions are near-term recommendations to guide the activities needed to accomplish the recovery objectives and achieve the recovery criteria. This Revised Recovery Plan presents 33 actions that address overall recovery through maintenance and restoration of spotted owl habitat, monitoring of avian diseases, development and implementation of a delisting monitoring plan, and management of the barred owl. These actions are organized following the five listing factors described earlier.

## Organization of Revised Recovery Plan

This Revised Recovery Plan is organized into four main sections with supporting appendices and retains the structure of the 2008 Plan. After Section I the Introduction, Section II gives a summary of recovery goals, objectives, and strategy. This section also gives an overview of how this recovery strategy for spotted owls fits within a broader ecosystem management approach. Section III describes recovery units, criteria, and the actions that are necessary to recover the species. These recovery actions are organized according to the five factors considered when a species is listed under section 4(a)(1) of the ESA. Section IV outlines the Plan's implementation schedule and cost estimates.

This Revised Recovery Plan also includes several appendices. These appendices provide background information, literature cited, a description of the spotted owl habitat modeling tool, and other important supporting information.

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# Acronyms and Abbreviations

| | |
|---|---|
| BLM | U.S. Bureau of Land Management |
| BOWG | Barred Owl Work Group |
| CAL FIRE | California Department of Forestry and Fire Protection |
| CDFG | California Department of Fish and Game |
| CI | confidence interval |
| $CO_2$ | carbon dioxide |
| dbh | diameter at breast height |
| DCA | Designated Conservation Area |
| DFLWG | Dry forest Landscape Work Group |
| ENSO | El Niño-Southern Oscillation |
| ESA | Endangered Species Act |
| FEMAT | Forest Ecosystem Management Assessment Team |
| FS | U.S. Forest Service |
| FWS | U.S. Fish and Wildlife Service |
| HCA | Habitat Conservation Area |
| HCP | Habitat Conservation Plan |
| ISC | Interagency Scientific Committee |
| KPWG | Klamath Province Work Group |
| LRMP | Land and Resource Management Plan (for BLM and FS) |
| LSR | Late-Successional Reserve |
| MOCA | Managed Owl Conservation Area |
| NPS | National Park Service |
| NRF | Nesting/roosting and foraging |
| NSO | Northern spotted owl |
| NSOIT | Northern Spotted Owl Implementation Team |
| NWFP | Northwest Forest Plan |
| ODF | Oregon Department of Forestry |
| PDO | Pacific Decadal Oscillation |
| SE | standard error |
| SEI | Sustainable Ecosystems Institute |
| SHA | Safe Harbor Agreement |
| SOSEA | Spotted Owl Special Emphasis Areas |
| TBD | to be determined |
| USFWS | U.S. Fish and Wildlife Service (Service) |
| USGS | U.S. Geological Survey |
| WDNR | Washington Department of Natural Resources |
| WNV | West Nile virus |

# I. INTRODUCTION

## Development of This Revised Recovery Plan

This Revised Recovery Plan builds extensively on the 1992 Draft Recovery Plan for the Northern Spotted Owl (USFWS 1992b), the 1994 NWFP (USDA and USDI 1994a, b), and the 2008 Recovery Plan for the Northern Spotted Owl (USFWS 2008b).

In 1993, President Clinton announced the NWFP which was intended to serve three roles: (1) a program to manage forests to achieve both sustainable timber production and protection of biological diversity; (2) a system for coordinating Federal agency implementation of the forest management efforts and receiving advice from non-federal interests; and (3) an initiative for providing economic assistance for those individuals and communities who were adversely affected by the reduction in the timber program. The 1994 NWFP signaled a unique approach to Federal land management in that it sought to embody (Pipkin 1998):

1. A shift to an ecosystem approach that crosses jurisdictional boundaries;
2. Active and meaningful public participation;
3. A balancing of commodity production and ecosystem viability;
4. Increased adaptive management efforts that support reevaluation and adjustments based on science;
5. A commitment to improved interagency processes; and
6. Federal agencies sharing responsibility for the implementation of a set of standards and guidelines for managing a common resource.

Due to its broad, over-arching nature and comprehensive scientific information, the 1994 NWFP was widely viewed as the Federal government's contribution to the recovery of the spotted owl since it contained the information used to develop the draft 1992 Northern Spotted Owl Recovery Plan. The NWFP was directly incorporated into 4 National Forest land and resource management plans (LRMPs) and amended the LRMPs or resource management plans (RMPs) that guide the management of each of the 15 National Forests and 6 Bureau of Land Management (BLM) Districts across the range of the spotted owl. These plans adopted a series of reserves and management guidelines that were intended to protect spotted owls and their habitat as well as other species.

As time passed, the public and land managers expressed a desire for a spotted owl recovery plan that explicitly outlined and described the management actions and habitat needs of the species. The U.S. Fish and Wildlife Service (Service) responded by publishing in May, 2008, the Recovery Plan for the Northern Spotted Owl, which was created after 2 years of scientific meetings, peer review, input from a wide variety of experts and more than 70,000 public comments.

The 2008 Recovery Plan identified two predominant threats: increasing competition from barred owls, and habitat loss from timber harvest and fire. The main elements of the 2008 Recovery Plan included: (1) a network of conservation areas on Federal lands west of the Cascade Crest; (2) a new approach to habitat management on Federal lands east of the Cascade Crest that maintains spotted owl habitat in a fire-prone landscape; (3) barred owl removal experiments; and (4) maintenance of substantially all older forests on Federal lands west of the Cascade Crest to reduce spotted owl and barred owl competitive interactions as we evaluate barred owl management options.

In June 2008, the Service received reviews of the 2008 Recovery Plan from the American Ornithologists' Union, Society for Conservation Biology and The Wildlife Society. These scientific peer reviews were consistent in their comments, noting that the recovery plan provided a "solid conceptual framework for recovery." However, the comments were critical of several key aspects of the 2008 Recovery Plan, particularly addressing threats posed by habitat loss from fire and concerns regarding the adequacy of reserves and their management.

Both the 2008 Recovery Plan and the 2008 revised critical habitat designation for the northern spotted owl, which is based on the 2008 Recovery Plan, were challenged in court, *Carpenters' Industrial Council v. Salazar*, 1:08-cv-01409-EGS (D.D.C.). In addition, on December 15, 2008, the Inspector General of the Department of the Interior issued a report entitled "Investigative Report of the Endangered Species Act and the Conflict between Science and Policy," which concluded that the integrity of the agency decision-making process for the 2008 Recovery Plan was potentially jeopardized by improper political influence. As a result, the Federal government filed a motion in the lawsuit for remand of the 2008 Recovery Plan and the 2008 critical habitat designation. On September 1, 2010, the Court issued an opinion remanding the 2008 Recovery Plan to the Service for issuance of a revised recovery plan within nine months. On May 6, 2011, the Court granted our request for a 30-day extension to allow time to consider the comments we received on Appendix C, which describes the modeling process, during an additional 30-day comment period. This Revised Recovery Plan is the result of the process to consider revisions to the 2008 Recovery Plan.

This Revised Recovery Plan is based on the best scientific information available, addressing the scientific peer reviewers' comments and including more recent scientific information involving climate change and habitat modeling. This Revised Recovery Plan focuses largely on five topics:

1. Conservation of spotted owl sites and high value spotted owl habitat;
2. Ecological forestry and active forest restoration to meet the challenges of climate change and altered ecological processes;
3. The threat posed by barred owls and management options to address it;
4. The potential need for State and private lands to contribute to spotted owl recovery in certain areas; and

5. Completion of a habitat modeling framework as an informational tool to better enable future land management decisions.

While this document retains some aspects of the 2008 Recovery Plan such as the strategy to assess and address threats from the barred owl and support for forest restoration treatments, it presents the most comprehensive, up-to-date evaluation of spotted owl science, conservation needs and management alternatives. With it, the Service seeks to engage Federal, State and private landowners in developing a comprehensive, landscape-level approach that furthers the recovery of the spotted owl.

The following is a chronology of the process involved in writing this Revised Recovery Plan.

- September 2010: 2010 Draft Revised Recovery Plan released for public comment and scientific peer review.
- Fall, 2010: Service holds eight stakeholder briefings and workshops regarding development of the habitat modeling tool.
- October 2010: Service posts to website a map depicting the results of the first two steps of the modeling tool.
- December 2010: Service posts summary results of the third step of the modeling tool.
- November 15, 2010: public comment period closes, but is extended until December 15, 2010.
- April 22, 2011: 30-day public comment period opened for review of and comment on updated spotted owl habitat modeling information contained in draft Appendix C.

# Recovery Planning and Timeframes

The Endangered Species Act of 1973, as amended (16 USC 1531 *et seq*.)(ESA), establishes policies and procedures for identifying and conserving species of plants and wildlife that are endangered or threatened with extinction. To help identify and guide species recovery efforts, section 4(f) of the ESA directs the Secretary of the Interior to develop and implement recovery plans for listed species. These plans are to include:

1. A description of site-specific management actions necessary for conservation and survival of the species;
2. Objective, measurable criteria that, when met, will allow the species to be delisted; and
3. Estimates of the time and funding required to achieve the plan's goals and intermediate steps.

*Recovery plans are not regulatory documents*; rather, they are created by the Service as guidance to bring about recovery and establish criteria to be used in

evaluating when recovery has been achieved. There may be many paths to recover a species. Recovering a wide-ranging species takes time and significant effort from a multitude of entities. Recovering a species is a dynamic process, and judging when a species is recovered requires an adaptive management approach that is sensitive to the best available information and risk tolerances. Given the adaptive nature of this iterative process, recovery may be achieved without fully following the guidance provided in this Revised Recovery Plan.

# Recovery Plan Objectives, Criteria, and Actions

The ultimate goal of this Revised Recovery Plan is to recover the spotted owl so that protections afforded by the ESA are no longer necessary, allowing us to delist the species. Its objectives describe a scenario in which the spotted owl's population is stable or increasing, well-distributed, and affected by manageable threats. To meet this goal and these objectives, interim expectations are defined to guide us as we learn more about the multiple uncertainties surrounding this species.

This Revised Recovery Plan was developed using the best scientific information available and a "step-down" approach of objectives, criteria and actions. Recovery objectives are broad statements that describe the conditions under which the Service would consider the spotted owl to be recovered. Recovery criteria serve as objective, measurable guidelines to assist in determining when an endangered species has recovered to the point that it may be downlisted to threatened, or that the protections afforded by the ESA are no longer necessary and the species may be delisted. Recovery actions are the Service's recommendations to guide the activities needed to accomplish the recovery criteria. Recovery actions are recommended throughout the U.S. range of the spotted owl and are designed to address the specific threats identified in this Revised Recovery Plan. Implementation of the full suite of recovery actions will involve participation from the States, Federal agencies, non-federal landowners and the public.

The recovery criteria and actions are described at the beginning of this Revised Recovery Plan. Information concerning the spotted owl's biology is in Appendix A, and a description of the threats to the spotted owl is presented in Appendix B.

# Five-year Status Reviews

A 5-year review of a listed species is required by section 4(c)(2) of the ESA, and considers all new available information concerning the population status of the species and the threats that affect it. This process can serve as an integral component of tracking recovery implementation, updating scientific understanding and evaluating status of the species. The Service conducts these periodic reviews to ensure the listing classification of a species as threatened or endangered is accurate. A 5-year status review considers the best scientific and commercial information that has become available since the original listing

determination or last review such as: species biology, habitat conditions, conservation measures, threat status and trends, and any other new information. The Service publishes a notice in the Federal Register announcing the initiation of these reviews and provides the public an opportunity to submit relevant information regarding the species and its threats.

A 5-year review is intended to indicate whether a change in a species listing classification is warranted. Changes in classification recommended in a 5-year review could include delisting, reclassification from threatened to endangered (*i.e.*, uplisting), reclassification from endangered to threatened (*i.e.*, downlisting), or no change is warranted at this time. The 5-year review does not involve rule-making, so no change to a species classification is made at the time a review is completed. If a change is recommended in the completed review, the Service would need to initiate a separate rule-making process to propose the change.

## Delisting Process

When sufficient progress toward recovery has been made, a separate effort will assess the spotted owl's status in relation to the five listing factors found in section 4(a)(1) of the ESA to determine whether delisting is appropriate (see Executive Summary). A change in status (downlisting or delisting) requires a separate rule-making process based on an analysis of the same five factors (referred to as the listing factors) considered in the listing of a species, as described in section 4(a)(1) of the ESA. These include:

A. The present or threatened destruction, modification, or curtailment of its habitat or range;
B. Overutilization for commercial, recreational, scientific, or educational purposes;
C. Disease or predation;
D. The inadequacy of existing regulatory mechanisms;
E. Other natural or manmade factors affecting its continued existence.

This subsequent review may be initiated without all of the recovery criteria in this Revised Recovery Plan having been fully met. For example, one or more criteria may have been exceeded, while other criteria may not have been fully accomplished. In this instance, the Service may judge that, overall, the threats have been minimized sufficiently and the species' population health is robust enough to be considered for delisting. If sufficient progress toward recovery has not been made, the spotted owl may retain its current status. If the spotted owl's condition deteriorates, it may be necessary to change its status to "endangered."

New recovery opportunities or scientific information may arise that were unknown at the time this Revised Recovery Plan was created. New opportunities may encompass more effective means of achieving recovery or measuring recovery. In addition, new information may alter the extent to which criteria need to be met for recognizing recovery of the species. Conversely, new information may result in new challenges, and achieving recovery may be more difficult than we now believe.

## Assumptions Made in Drafting the Revised Recovery Plan

There are numerous land management plans and strategies being implemented to help recover the spotted owl. This Revised Recovery Plan is not meant to negate or supplant these other plans. However, these plans may be subject to change, so this Revised Recovery Plan is meant to be a stand-alone document that describes steps necessary to recover the spotted owl. The recommendations described in the Revised Recovery Plan are meant to be successful on their own; that is, they are not dependent on the continuance of any other conservation or management plan to be successful, unless specifically noted.

**Implementation of the full suite of recovery actions will involve participation from the States, Federal agencies, non-federal landowners and the public.**

## Listing History and Recovery Priority

The spotted owl was listed as threatened on June 26, 1990. On a scale of 1C (highest) to 18 (lowest) (USFWS 1983a, b), the Service recovery priority number for the spotted owl is 12C. We assigned this number per our guidelines for the following reasons: the spotted owl faces a "moderate" degree of threat which equates to a continual population decline and threat to its habitat, although extinction is not imminent. It received a "low recovery potential" because there is uncertainty regarding our ability to alleviate the barred owl impacts to spotted owls and the techniques are still experimental; and because of the spotted owl's taxonomic status as a subspecies and inherent conflicts with development, construction, or other economic activity given the economic value of older forest spotted owl habitat (USFWS 1983a, b). Despite the definitions that led us to a 12C Recovery priority number, the Service is optimistic regarding the spotted owl's potential for recovery if immediate challenges such as barred owls are managed.

**The spotted owl was listed in 1990 as a result of widespread loss and adverse modification of spotted owl habitat across its entire range and the inadequacy of existing regulatory mechanisms to conserve the spotted owl.**

## Reasons for Listing and Assessment of Threats

The spotted owl was listed as threatened throughout its range "due to loss and adverse modification of spotted owl habitat as a result of timber harvesting and exacerbated by catastrophic events such as fire, volcanic eruption, and wind storms" (USFWS 1990b:26114). More specifically, threats to the spotted owl included low populations, declining populations, limited habitat, declining

habitat, inadequate distribution of habitat or populations, isolation of populations within physiographic provinces, predation and competition, lack of coordinated conservation measures, inadequacy of regulatory mechanisms and vulnerability to natural disturbance (USFWS 1992b). These threats were characterized for each province as severe, moderate, low or unknown (USFWS 1992b). The range of the spotted owl is divided into 12 physiographic provinces from Canada to northern California and from the Pacific Coast to the eastern Cascades (see Appendix A, Figure A-1). Declining habitat was recognized as a severe or moderate threat to the spotted owl throughout its range, isolation of populations was identified as a severe or moderate threat in 11 provinces, and a decline in population was a severe or moderate threat in 10 provinces. Together, these three factors represented the greatest concerns about range-wide conservation of the spotted owl. Limited habitat was considered a severe or moderate threat in nine provinces, and low populations was a severe or moderate concern in eight provinces, suggesting that these factors were also a concern throughout the majority of the spotted owl's range. Vulnerability to natural disturbances was rated as low in five provinces.

The Service conducted a 5-year review of the spotted owl in 2004 (USFWS 2004b), based in part on the content of an independent scientific evaluation of the status of the spotted owl (Courtney *et al.* 2004) performed under contract with the Service. For that evaluation, an assessment was conducted of how the threats described in 1990 might have changed by 2004. Some of the key ideas relative to threats identified in 2004 were: (1) "Although we are certain that current harvest effects are reduced, and that past harvest is also probably having a reduced effect now as compared to 1990, we are still unable to fully evaluate the current levels of threat posed by harvest because of the potential for lag effects" (Courtney and Gutiérrez 2004:11-7); (2) "Currently the primary source of habitat loss is catastrophic wildfire, although the total amount of habitat affected by wildfires has been small" (Courtney and Gutiérrez 2004:11-8); and (3) "We are convinced that Barred Owls are having a negative impact on Spotted Owls at least in some areas" (Gutiérrez *et al.* 2004:7-43) and "there are no grounds for optimistic views suggesting that Barred Owl impacts on Northern Spotted Owls have been already fully realized" (Gutiérrez *et al.* 2004:7-38).

On June 1, 2006, we convened a meeting of seven experts to help identify the most current threats facing the species. Six of the seven were experts on the biology of the spotted owl, and a seventh was an expert on fire ecology. The workshop was conducted as a modified Delphi expert panel in which the seven experts scored the severity of threat categories. The baseline assumption of this meeting was that existing habitat conservation strategies (*e.g.,* the NWFP) would be in place. With that assumption, the experts identified and ranked threats to the spotted owl. The 2007 Recovery Team then had an opportunity to interact with them to discuss their individual rankings and thoughts on spotted owl threats. The experts re-ranked the threats if they felt this was relevant given the substance of the discussion.

These experts identified past habitat loss, current habitat loss, and competition from barred owls as the most pressing threats to the spotted owl, even though

timber harvest recently has been greatly reduced on Federal lands. They noted that evidence of these three threats is presented in the scientific literature. The range of threat scores made by the individual experts was narrowest for barred owl competition and slightly greater for habitat threats, indicating that there was more agreement about the threat from barred owls. The experts identified disease and the effect of climate change on vegetation as potential and more uncertain future threats.

The experts also ranked the threats by importance in each province. Among the 12 physiographic provinces, the more fire-prone provinces (Eastern Washington Cascades and Eastern Oregon Cascades, California Cascades, Oregon and California Klamath) scored high on threats from ongoing habitat loss as a result of wildfire and the effects of fire exclusion on vegetation change. West-side provinces (Western Washington Cascades and Western Oregon Cascades, Western Washington Lowlands, Olympic Peninsula, and Oregon Coast Range) generally scored high on threats from the negative effects of habitat fragmentation and ongoing habitat loss as a result of timber harvest. The province with the fewest number of threats was Western Oregon Cascades, and the provinces with the greatest number of threats were the Oregon Klamath and the Willamette Valley. For a more complete description of the threats, see Appendix B.

## Barred Owls

It is the Service's position that the threat from barred owls is extremely pressing and complex, requiring immediate consideration. Barred owls have been found in all areas where surveys have been conducted for spotted owls. In addition, barred owls inhabit all forested areas throughout Washington, Oregon, and northern California where nesting opportunities exist, including areas outside of the specific range of the spotted owl (Kelly and Forsman 2003, Buchanan 2005, Gutiérrez *et al.* 1995, 2007, Livezey 2009a). Consequently, the Service assumes barred owls now occur at some level in all areas used now or in the past by spotted owls.

**The workshop panel unanimously identified past habitat loss, current habitat loss, and competition from barred owls as the most-pressing threats to the spotted owl, even though timber harvest recently has been greatly reduced on Federal lands.**

Addressing the threats associated with past and current habitat loss must be conducted simultaneously with addressing the threats from barred owls. Addressing the threat from habitat loss is relatively straightforward with predictable results. However, addressing a large-scale threat of one raptor on another, closely related raptor has many uncertainties.

At this time, the long-term removal of significant numbers of barred owls, along with a suite of other recovery actions, will be assessed as a possible approach to recover the spotted owl. Before considering whether to fund and fully implement such an action, however, the Service needs to be confident this

removal would benefit spotted owls. The Service is currently developing a draft Environmental Impact Statement to assess the effects of barred owl removal experiments proposed in this Revised Recovery Plan.

Because barred owls compete with spotted owls for habitat and resources for breeding, feeding and sheltering, ongoing loss of habitat has the potential to intensify the competition by reducing the total amount of these resources available to the spotted owl and bringing barred owls into closer proximity with the spotted owl. In order to reduce or not increase this potential competitive pressure while the threat from barred owls is being addressed, this Revised Recovery Plan now recommends conserving and restoring older, multi-layered forests across the range of the spotted owl.

## Habitat Management

In addition to addressing the barred owl threat, the Service agrees with scientific experts that it is necessary to conserve the highest value spotted owl habitat to address the key threats. The 2008 Recovery Plan recommended establishing Managed Owl Conservation Areas (MOCAs) on Federal lands to provide the important habitat needed for the species to recover over the long-term. The Service is not making this recommendation in this Revised Recovery Plan. Instead, we rely on the habitat conservation network of the NWFP, in addition to other habitat conservation recommendations contained within this Revised Recovery Plan. In addition, we have completed a range-wide, multi-step habitat modeling tool, described in Appendix C, that will help evaluate and inform the Service's designation of critical habitat, and the development of future land management plans by Federal land managers, and the consideration of management options by State, Tribal, or private landowners as recommended by this Revised Recovery Plan.

In addition, given the continued decline of the species, the apparent increase in severity of the threat from barred owls, and information indicating a recent loss of genetic diversity for the species, this Revised Recovery Plan also recommends retaining more occupied spotted owl sites and unoccupied, high value spotted owl habitat on all lands. Vegetation management actions that may have short-term impacts but are potentially beneficial to occupied spotted owl sites in the long-term meet the goals of ecosystem conservation. Such actions may include silvicultural treatments that promote ecological restoration and are expected to reduce future losses of spotted owl habitat and improve overall forest ecosystem resilience to climate change, which should result in more habitat retained on the landscape for longer periods of time.

In the more disturbance-prone provinces on the east side of the Cascade Mountains and in the Klamath Province, the Dry Forest Landscape and Klamath Province Work Groups (these are recovery implementation teams established as recommended by the 2008 Recovery Plan) are working to develop strategies that incorporate the dynamic natural disturbance regime in a manner that provides for long-term ecological sustainability through the restoration of ecological

processes while conserving spotted owl habitat over the long-term. Some land management units, such as the Okanagan-Wenatchee National Forest, have published such strategies (USDA 2010).

# II. RECOVERY GOAL, OBJECTIVES, CRITERIA, AND STRATEGY

## Recovery Goal

The long-term goal of this recovery plan is to improve the status of the spotted owl so it can be removed from protection under the ESA.

## Recovery Objectives

The objectives of this Revised Recovery Plan are:

1. Spotted owl populations are sufficiently large and distributed such that the species no longer requires listing under the ESA;
2. Adequate habitat is available for spotted owls and will continue to exist to allow the species to survive without the protection of the ESA; and
3. The effects of threats have been reduced or eliminated such that spotted owl populations are stable or increasing and spotted owls are unlikely to become threatened again in the foreseeable future.

## Recovery Criteria

There are four recovery criteria in this Revised Recovery Plan. Recovery criteria are measurable, achievable goals that we believe will result from implementation of the recovery actions in this Revised Recovery Plan. Achievement of these criteria will take time and is intended to be measured over the life of the plan, not on a short-term basis and should not be considered near-term recommendations. This plan is designed to meet these criteria at which time the Service will make a decision about whether to propose delisting the spotted owl. Not all recovery actions need to be implemented and not all recovery criteria need to be fully achieved for the Service to consider delisting.

**Recovery Criterion 1 - Stable Population Trend:** The overall population trend of spotted owls throughout the range is stable or increasing over 10 years, as measured by a statistically-reliable monitoring effort.

**Recovery Criterion 2 – Adequate Population Distribution:** Spotted owl subpopulations within each province (*i.e.*, recovery unit) (excluding the Willamette Valley Province) achieve viability, as informed by the HexSim population model or some other appropriate quantitative measure.

**Recovery Criterion 3 – Continued Maintenance and Recruitment of Spotted Owl Habitat:** The future range-wide trend in spotted owl nesting/roosting and

foraging (NRF) habitat is stable or increasing throughout the range, from the date of Revised Recovery Plan approval, as measured by effectiveness monitoring efforts or other reliable habitat monitoring programs.

**Recovery Criterion 4 – Post-delisting Monitoring:** To monitor the continued stability of the recovered spotted owl, a post-delisting monitoring plan has been developed and is ready for implementation within the States of Washington, Oregon, and California (as required by section 4(g)(1) of the ESA).

## Recovery Strategy

Currently, the most important range-wide threats to the spotted owl are competition with barred owls, ongoing loss of spotted owl habitat as a result of timber harvest, loss or modification of habitat from uncharacteristic wildfire, and loss of amount and distribution of spotted owl habitat as a result of past activities and disturbances. To address these threats, this recovery strategy includes five basic steps:

1. Development of a range-wide habitat modeling framework;
2. Barred owl management;
3. Monitoring and research;
4. Adaptive management; and
5. Habitat conservation and active forest restoration.

These five steps are described in detail below.

## Development of Range-wide Habitat Modeling Framework

The first step in this recovery strategy is to develop a state-of-the-science modeling framework for evaluating spotted owl habitat and populations. Scientific peer reviewers were critical of the 2008 Recovery Plan's MOCA reserve strategy and the general lack of updated habitat modeling capacity. The Service agreed with this concern; the MOCA recommendation is not contained in this Revised Recovery Plan.

When listed as threatened in 1990 (USFWS 1990), habitat loss and fragmentation of old-growth forest were identified as major factors contributing to declines in spotted owl populations. As older forest became reduced to smaller and more isolated patches, the ability of spotted owls to successfully disperse and establish territories was reduced (Lamberson *et al.* 1992). Lamberson *et al.* (1992) identified that there appeared to be a sharp threshold in the amount of habitat below which spotted owl population viability plummeted. In order to promote spotted owl recovery, earlier plans including the 1992 Draft Recovery Plan for the Northern Spotted Owl (USFWS 1992) and the Northwest Forest Plan (USDA and USDI 1994) established spotted owl habitat reserve networks to promote species recovery. The goal of these conservation reserves was to achieve a high likelihood of long-term persistence while minimizing impacts on resources with

economic value. For territorial species such as the spotted owl, Lamberson *et al.* (1994) concluded that size, spacing and shape of reserved areas all had strong influence on population persistence, and reserves that could support a minimum of 20 spotted owl territories were more likely to maintain spotted owl populations than smaller reserves. They also found that juvenile dispersal was facilitated in areas large enough to support at least 20 spotted owl territories. In addition to size, spacing between reserves had a strong influence on successful dispersal (Lamberson *et al.* 1992). Forsman *et al.* (2002) reported dispersal distances of 1,475 spotted owls in Oregon and Washington for 1985–1996. Median maximum dispersal distance (the straight-line distance between the natal site and the farthest location) for radio-marked juvenile male spotted owls was 12.7 miles, and that of female spotted owls was 17.2 miles (Forsman *et al.* 2002: Table 2). Dispersal data and other studies on the amount and configuration of habitat necessary to sustain spotted owls provided the foundation for developing previous spotted owl habitat reserve systems.

Although we are not recommending a new habitat conservation network, we recommend utilizing the best available information, including modeling data, to evaluate and refine such a network that will continue to support the recovery of the spotted owl. The NWFP currently provides a network of reserve land use allocations that protects habitat for late-successional forest species, including the demographic and dispersal needs of the spotted owl. Anthony *et al.* (2006) and Forsman *et al.* (2011) have reported that demographic rates for spotted owls on long-term Federal monitoring areas that contained late-successional reserves were higher than those from other long-term study areas. We believe a habitat conservation network designed using the best available science is necessary to recover the spotted owl. The NWFP reserve network, in addition to other habitat conservation recommendations in this Revised Recovery Plan (*e.g.*, Recovery Actions 10, 32 and 6), meets that need in the near term until the Forest Service and BLM revise their respective management plans. We recommend that any future revisions in Federal land management plans take into account the need for appropriately spaced, large habitat conservation areas for spotted owls. The upcoming critical habitat revision process will help identify whether any additional areas or adjustments to that network are warranted.

Therefore, we recommend continued application of the reserve network of the NWFP until the 2008 designated spotted owl critical habitat is revised and/or the land management agencies amend their land management plans taking into account the guidance in this Revised Recovery Plan. We have developed a modeling framework that can provide information for numerous spotted owl recovery actions and management decisions, including revisions to the spotted owl critical habitat designation. This spatially-explicit modeling effort is designed to allow for a more in-depth evaluation of various habitat features that affect the distribution of spotted owl territories and the factors influencing spotted owl populations. Different land management scenarios can then be evaluated for their relative potential contribution to spotted owl recovery. This modeling effort is described in detail in Appendix C. The Service hopes this modeling framework or similar approaches will be used by Federal, State, and

private scientists to make better informed decisions concerning what areas should be conserved for spotted owls.

## Barred Owl Management

The second step in this recovery strategy is to move forward with a scientific evaluation of potential management options to reduce the impact of barred owls on spotted owls. Barred owls pose perhaps the most significant short-term threat to spotted owl recovery. This threat is better understood now than when the spotted owl was listed. Barred owls have reduced spotted owl site occupancy, reproduction, and survival. Because the abundance of barred owls continues to increase, effectively addressing this threat depends on initiating action as soon as possible. The recovery actions address research involving the competition between spotted and barred owls, experimental control of barred owls and, if recommended by research, management of barred owls. Discussion of the barred owl threat occurs throughout this document, especially in Listing Factor E and Appendix B.

## Monitoring and Research

The third step in this recovery strategy is to continue implementing a robust monitoring and research program for the spotted owl. This Revised Recovery Plan recommends activities be implemented to track progress toward recovery, to inform changes in recovery actions by a process of adaptive management, and ultimately to help determine when delisting is appropriate. The following primary elements of this strategy will provide information required to evaluate progress toward the Recovery Criteria. The monitoring and research results can be considered within the 5-year review process which is required under the ESA.

## Monitoring of Spotted Owl Population Trend

Currently, this monitoring is done within a network of demographic study areas, but it may be possible to monitor trends using other reliable methods. Recognizing that the demographic monitoring efforts are costly, it is recommended that, in the absence of another method that would provide reliable trend data at an improved cost-effectiveness, these existing studies should be continued while other methods are piloted and tested. The current demographic studies provide region-specific demographic data that provide the basis for many of the current and proposed studies of spotted owl ecology. Also, because monitoring in the demographic study areas has been ongoing for approximately two decades, the data from these efforts allow trend estimates in the near-term that would not be available for a considerable length of time if new methods were implemented.

## A Comprehensive Effort of Barred Owl Research and Monitoring

This is needed to experimentally determine the effects of barred owls on spotted owls and to incorporate this information into management to reduce negative effects to a level that would promote spotted owl recovery.

Given the immediacy of the barred owl threat, the continuation of monitoring in the demographic study areas provides a timely opportunity to integrate barred owl removal experiments to assess any demographic response of spotted owls to removal of barred owls. Assessing the demographic response will help the Service determine whether the effects of this threat could be reduced or eliminated by a larger-scale control program.

## Continued Habitat Monitoring

The Effectiveness Monitoring program initiated by the NWFP includes tracking the status and trends of spotted owl habitat (Davis and Lint 2005). This monitoring program will allow us to assess progress towards meeting **Recovery Criterion 3: Continued Maintenance and Recruitment of Spotted Owl Habitat** and help the Service determine whether the threat of habitat loss has been reduced or eliminated such that spotted owls are unlikely to become threatened again in the foreseeable future.

## Inventory of Spotted Owl Distribution

The recovery of the spotted owl is predicated on maintaining the current rangewide distribution of the species within each of the 12 provinces (see Recovery Unit discussion). When trend data indicate that populations are stable or increasing in the provinces as specified in Recovery Criterion 1, sampling should also be considered to evaluate spotted owl distribution in all provinces.

## Explicit Consideration for Climate Change Mitigation Goals Consistent with Spotted Owl Recovery Actions

There is significant overlap between many of the spotted owl recovery goals described in this Revised Recovery Plan and opportunities to mitigate impacts due to climate change. The Service is applying Secretarial Order No. 3289: *Addressing the Impacts of Climate Change on America's Water, Land, and Other Natural and Cultural Resources* into our forest management activities. This Secretarial Order directs DOI agencies to analyze potential climate change impacts when undertaking long-range planning exercises, developing multi-year management plans, and making major decisions regarding potential use of resources under the Service's purview. This direction applies to this Revised

Recovery Plan, which includes a detailed treatment of climate change and its potential impact on spotted owl recovery.

# Adaptive Management

## Risk, Uncertainty and Changing Management

When writing a recovery plan, the Service must use the best scientific information available. However, the information available rarely addresses all of the questions at hand, meaning there is usually some degree of uncertainty. Hence, recovery plans include an element of risk management (especially for wide-ranging species which face a multitude of threats) because the Service must make recommendations and decisions in the face of incomplete information and uncertainty.

In the face of significant scientific uncertainty, we propose aggressive strategies to address the threats from habitat loss, barred owls and climate change. It is understood that this Revised Recovery Plan's expression of risk, as embodied by the recovery strategy and actions, may not match the risk tolerance of every interested party. However, it is the conclusion of the Service that the actions in this Revised Recovery Plan are necessary to achieve the plan's goal for the conservation and survival of the species.

In order to deal with uncertainty and risk the Service will employ an active program of adaptive management. Adaptive management includes identifying areas of uncertainty and risk, implementing a research and monitoring approach to clarify these areas, and making decisions to change management direction that is not working while still maintaining management flexibility (see Thomas *et al.* 1990, USFWS 1992b). Where possible, the implementation of the recovery actions included within this Revised Recovery Plan should be designed in a manner that provides feedback on the efficacy of management actions such that the design of future actions can be improved.

## What is Adaptive Management?

Adaptive management is a systematic approach for improving resource management by learning from the results of explicit management policies and practices and applying that learning to future management decisions (Holling 1978, Walters 1986, Gregory *et al*. 2006). This tool is useful when there is substantial uncertainty about appropriate strategies for managing natural resources. Although adaptive management is a form of "learning by doing," its purposefulness and systematic approach distinguish it from learning by trial and error where management direction changes in the face of failed policies and actions (Stankey *et al*. 2005, Gregory *et al.* 2006). Bormann *et al.* (2007:187)

provide a practical description of and purpose for adaptive management:

> "Adaptive management requires exploring alternative ways to meet management objectives, predicting the outcomes of alternatives based on what is known, implementing one—or if possible, more than one—of these alternatives, monitoring to learn which alternative best meets the management objectives, and then using results to update knowledge and adjust management actions. Adaptive management is not an end in itself, but a means to more effective decisions and enhanced benefits; thus, its true measure is in how well it helps meet environmental, social, and economic goals, adds to scientific knowledge, and reduces tensions among stakeholders."

Key components of adaptive management include: (1) treating management actions and policies as formal experiments that yield new information; (2) embracing risk and uncertainty as opportunities for learning; and (3) applying the knowledge gained from management experiments to subsequent actions (Holling 1978, Stankey *et al*. 2003, Stankey *et al.* 2005). We elaborate on each of these components below.

Treating management actions as experiments is a fundamental component of the adaptive management process. Key to this is clearly articulating questions about the effects of implementing management actions, formally re-casting these questions as testable hypotheses, implementing them as experiments to be tested, and monitoring the results. Yet this is often where the process fails. For example, in a critique of the NWFP adaptive management program, Stankey *et al*. (2003) found a major fault to be a predominant reliance on decision-making approaches that were informal and incremental, yet widely accepted as an adaptive management approach. Articulating measurable management objectives and forming them into explicit hypotheses that can be tested is what ultimately separates adaptive management from learning by trial and error.

The second key component in successfully implementing adaptive management, as identified above, requires embracing risk and uncertainty as opportunities for learning. The need for adaptive management is driven by the existing uncertainty surrounding appropriate management treatments and how ecosystems may respond to those treatments. A risk-averse mentality of not acting until more information is known may ultimately result in implementing ongoing, ineffectual policies that may not only further threaten resources of concern, but also suppress experimental actions that could provide learning to inform and improve future management. While there are costs and risks in applying experimental treatments, failing to experiment also carries costs and risks (Wildavsky 1988, as cited in Stankey *et al*. 2003). As Stankey *et al*. (2003:45) noted, "The irony here is that while continuation of policies that have not worked seems to ensure continued failure, undertaking actions where outcomes are uncertain is resisted because of the inability to ensure that unwanted effects will not result." Testing clearly formed hypotheses in a systematic manner under identifiable, bounded settings and monitoring the outcomes will go far in

improving future management and developing more resilient policies while minimizing risk to resources.

The knowledge gained from testing hypotheses must be documented and applied to future actions if learning is to happen and if the policy or decision-making process is to be informed and improved. Thus, it is vital that the question asked as part of the experiment is relevant to managers. To speed the pace of learning, Williams *et al.* (2009) recommend that alternative management options be applied and tested, and that these options are sufficiently different to produce observable responses that can be detected by monitoring.

## Goals and Steps in an Adaptive Management Process for the Spotted Owl

The overarching purpose of implementing adaptive management for spotted owl recovery is to reduce key scientific uncertainties with respect to spotted owl management and recovery and apply that knowledge to future spotted owl management decisions. An adaptive management program must deliver biological and ecological information relevant to spotted owl recovery; key objectives to facilitate this need are:

1. Identify and fill key gaps in our knowledge base
2. Improve our understanding of ecosystem responses, thresholds and dynamics
3. Learn about the effectiveness of alternate management policies and activities
4. Document and disseminate the knowledge gained so that it is available in future management

Several sources of information are available that outline steps in designing and implementing adaptive management programs (Williams *et al.* 2009, BCMFR undated). Typical steps in adaptive management include:

1. Assess and define the problem – including defining measurable management objectives and potential management treatments, along with key indicators and projected responses for each objective.

2. Design the management treatment and monitoring plan – including clarifying response thresholds that will trigger management adjustments, and identifying which management adjustments are needed.

3. Implement the management treatment and monitoring program – including documenting any deviation from the plan.

4. Monitor treatment implementation and results following the protocol designed in Step 2.

5. Evaluate results – including comparing outcomes to forecasts made in Step 1, as well as communicating results to others facing similar management issues.

6. Adjust or revise hypothesis and management as necessary – including identifying where uncertainties have been reduced and where they remain unresolved, as well as adjusting the model used to predict outcomes developed in Step 1 so that it reflects the hypothesis supported by the results.

The Service encourages existing recovery plan work groups to develop Steps 1 and 2 in the above adaptive management steps for problems relevant to their chartered tasks. Developing a clearly articulated problem and objective statement, combined with an implementation and monitoring plan, will provide an adaptive management framework that allows us to learn from future management activities. Work groups will forward frameworks to the Service for presentation to the Regional Interagency Executive Committee for consideration at the executive level under the existing Northwest Forest Plan process. The Service will work with these agencies to look for opportunities to implement Steps 3 through 6 of the above adaptive management steps consistent with the framework developed under Steps 1 and 2.

Below is a list of potential questions that may drive development of an adaptive management framework. It is not meant to be comprehensive, nor is it necessarily a prioritized list. Further articulation of these questions may be needed to develop frameworks that will be most informative. Additional questions are expected to arise as the Revised Recovery Plan is implemented. For example, results gleaned from Recovery Action 8, as well as implementation of the modeling process described in Appendix C, are expected to provide additional questions for adaptive management.

Questions that may for consideration under adaptive management include:

- What vegetation management treatments best accelerate the development of forest structure associated with spotted owl habitat functions while maintaining or restoring natural disturbance and provide greater ecosystem resiliency? What are the effects of these vegetation management treatments on spotted owl occupancy, demography, and habitat use immediately following treatment and at specified time periods after treatment? What are the effects of these treatments on spotted owl prey abundance and availability immediately following treatments and at specified time periods after treatment? What are the effects of the above vegetation management treatments on the habitat components that spotted owls and their prey use? How effective are these vegetation management treatments in developing desired forest structure and how long does this development take?

- What are the effects of wildland and prescribed fire on the structural elements of spotted owl habitat (compare burned and unburned areas, as well as different fire severities)? What are the effects on spotted owl habitat use? What are the effects of these fires on abundance of spotted owl prey? How does the scale of high severity burn patches affect foraging use by spotted owls? How does the

pattern and distribution of burned and unburned patches, or patches of differing burn severities, affect spotted owl use for foraging, roosting, and nesting?

- Can strategically-placed restoration treatments be used to reduce the risk of spotted owl habitat being burned by high severity fire within dry forest ecosystems?
- What are the effects of epidemic forest insect outbreaks on spotted owl occupancy and habitat use immediately following the event and at specified time periods after treatment?
- What is the nature of the competitive interaction between spotted and barred owls, and how might those interactions be managed in terms of direct intervention (*e.g.*, barred owl control) or indirectly through habitat management (*e.g.*, vegetation management treatments)?

## Habitat Conservation and Active Forest Restoration

The fifth component of this recovery strategy is derived from the stated purpose of the ESA: "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." Consistent with this purpose, it is the Service's goal that this spotted owl recovery strategy be embedded within -- and be consistent with -- a broader framework of conservation of forest ecosystems for the Pacific Northwest. This approach will provide more resilient forested habitat in the face of climate change and other stressors, thereby conserving more spotted owl habitat on the landscape for longer periods of time. Species-specific needs of the spotted owl should not be the sole determinant of landscape management decisions. Rather, spotted owl recovery objectives should fit within a broader strategy whose goals include the conservation of the full assemblage of species and ecological processes in that landscape so that it will be more resilient to future losses of spotted owl habitat or ecosystem change resulting from climate change and other disturbances.

The NWFP was developed to meet this goal for spotted owls and many other late-successional forest species. It continues to provide the basic landscape conservation framework for Federal lands in the range of the spotted owl (Noon and Blakesley 2006, Strittholt *et al.* 2006, Spies *et al.* 2010a,b), and the recommendations in this Revised Recovery Plan affirm and build upon the scientific principles of the NWFP. These principles include managing for the maintenance of ecological processes and applying adaptive management strategies to gain new scientific insight (FEMAT 1993, pg. VIII-5).

Although spotted owl recovery still relies heavily upon the principles of the NWFP as its foundation, there have been several significant developments that affect spotted owl recovery since the NWFP was first implemented 17 years ago. These include:

- *The continued decline of the spotted owl populations and low occupancy rates in large habitat reserves, and the growing negative impact from barred owl invasions of spotted owl habitats* (Forsman *et al.* 2011, Dugger *et al.* in press), *which is greater than anticipated in the NWFP*. We recommend increased conservation and restoration of spotted owl sites and high-value spotted owl habitat to help ameliorate this impact.
- *Climate change combined with effects of past management practices are exacerbating changes in forest ecosystem processes and dynamics, including patterns of wildfires, insect outbreaks and disease, to a degree greater than anticipated in the NWFP* (Perry *et al*. 2011). Land managers need to consider this uncertainty and how best to integrate knowledge of management-induced landscape pattern and disturbance regime changes with climate change when making spotted owl management decisions.
- *Scientific principles of forest management continue to evolve since implementation of the NWFP. "Ecological forestry," "natural disturbance-based management," "resilience management" and other related perspectives have emerged as accepted forest management approaches* (Long 2009, Moritz *et al.* 2011). We recommend spotted owl management decisions be implemented within a broader landscape approach based on the conservation of natural ecological patterns and processes.

These issues are not mutually exclusive, and spotted owl recovery depends on the integration of all three. Extant, high-quality spotted owl habitat must be managed, restored, and conserved in the face of a declining population and the potential threats from barred owls. Active, restoration-focused management to address climate change and dynamic ecosystem processes is also necessary in many areas, with the goal of maintaining or restoring forest ecosystem structure, composition and processes so they are sustainable and resilient under current and future climate conditions. Each of these issues is described in more detail below, and site-specific recommendations addressing these issues are contained in various recovery actions later in this Revised Recovery Plan.

This Recovery Strategy requires action in the face of uncertainty. We agree with Carey (2007, pg. 345, 349): "(A)ctive management for ecological values trades short-term negative effects for long-term gains…Collaborative management must be willing to accept short-term impacts and short-term risks to achieve long-term benefits and long-term risk reduction; overly zealous application of the precautionary principle often is a deliberate, conscious management decision to forego long-term increases in forest health and resilience to avoid short-term responsibility or controversy."

In other words, land managers should not be so conservative that, to avoid risk, they forego actions that are necessary to conserve the forest ecosystems that are necessary to the long-term conservation of the spotted owl. But they should also not be so aggressive that they subject spotted owls and their habitat to treatments where the long-term benefits do not clearly outweigh the short-term risks. Finding the appropriate balance to this dichotomy will remain an ongoing

challenge for all who are engaged in spotted owl conservation. All Federal actions will be subject to section 7 consultation allowing for site-specific analyses of the effect on spotted owls.

If carefully applied, we believe this Recovery Strategy and the recommendations in this Revised Recovery Plan will recover the spotted owl and sustain its recovery in the long-term by conserving the ecosystem upon which it relies. We also believe this approach is a land management perspective that is embraced by most forest ecologists and biologists and is well published in the scientific literature. It builds on what is already occurring in parts of the Pacific Northwest (see USDA 2010 and Gaines *et al.* 2010) and is consistent with the basic tenets of the NWFP. It provides opportunities for land managers to address multiple management goals in an integrated fashion, including recovery of the spotted owl, conservation of other fish and wildlife species, habitat restoration, fuels management, and timber production. It may also provide a common ground where adversarial stakeholders in the forest management debate can find some agreement and move forward.

# III. Recovery Units, Criteria, and Actions

## Recovery Units

Unlike previous versions of the spotted owl recovery plan, this Revised Recovery Plan identifies discrete recovery units throughout the entire range of the spotted owl such that each unit provides an essential survival and recovery function for the species. Recovery units defined on this basis are useful for purposes of managing the species and for applying the jeopardy standard under section 7 of the ESA to proposed Federal actions (USFWS and NMFS 1998, NMFS and USFWS 2010). When a proposed Federal action is likely to impair or preclude the capacity of a recovery unit to provide both the survival and recovery function it provides, that action may represent jeopardy to the species, provided the analysis describes not only how the action affects the recovery unit's capability but also the relationship of the recovery unit to both the survival and recovery of the listed species as a whole (NMFS and USFWS 2010).

In this Revised Recovery Plan, recovery units differ from management units, and are also not synonymous with critical habitat units; the former is a unit of the listed species, the latter is a unit of the species' habitat.

The recovery units defined in this Revised Recovery Plan are intended to assist managers in re-establishing or maintaining: (1) historical or current genetic flow between spotted owl populations; (2) current and historic spotted owl population and habitat distribution; and (3) spotted owl meta-population dynamics. Because the recovery units are defined on a biological basis, the recovery criteria for the spotted owl address each identified recovery unit.

In 1990, the Interagency Scientific Committee decided to subdivide the range of the spotted owl into "smaller areas for practical and analytical purposes" and used the physiographic provinces as a basis for their analysis (Thomas *et al.* 1990: 61). The physiographic provinces (also referred to as "provinces") incorporate physical, biological and environmental factors that shape broad-scale landscapes. The provinces reflect differences in geology (*e.g.*, uplift rates, recent volcanism, tectonic disruption) and climate (*e.g.*, precipitation, temperature, glaciation). In turn, these factors result in broad-scale differences in soil development, natural plant communities and ultimately, forest zones. Studies have demonstrated biological differences in the numbers, distribution, habitat use patterns, and prey of spotted owls relative to the different forest zones that occur within its range (Thomas *et al.* 1990). The Northern Spotted Owl Recovery Team (USFWS 1992b) divided the range of the spotted owl into 12 provinces based on differences in vegetation, soils, geologic history, climate, land ownership and political boundaries.

Given the above definitions and background information, the physiographic provinces meet the criteria for use as recovery units (see Figure A-1 in Appendix

A). The provinces collectively cover the range of the species, and each is essential for the conservation of the spotted owl (Thomas *et al.* 1990). The provinces are based on physical, biological and environmental factors that affect spotted owl numbers, distribution, habitat use patterns, habitat conditions, and prey species abundance. These provinces have been scientifically accepted, have been in use since 1990, and are integrated into management regimes and administrative purposes. In addition, most of the physiographic provinces contain long-term monitoring areas for the spotted owl, which yield robust scientific information to assess population dynamics and trends within each area and provide a good basis for analysis at recovery-unit and range-wide scales. Their long-standing monitoring information, biological basis and accepted use by managers should lead to an efficient transition to their adoption as recovery units. Using this rationale, we are proposing to adopt the physiographic province designations in place since 1990 as recovery units, with the exception of the Willamette Valley province, which is comprised largely of non-habitat for the spotted owl.

## Recovery Criteria

Recovery criteria serve as objective, measurable guidelines to assist in determining when an endangered species has recovered to the point that it may be downlisted to threatened, or that the protections afforded by the ESA are no longer necessary and the species may be delisted. However, meeting all or most of the recovery criteria does not automatically result in delisting, and does not meeting all criteria preclude delisting. A change in status (downlisting or delisting) requires a separate rule-making process based on an analysis of the same five factors (referred to as the listing factors) considered in the listing of a species, as described in section 4(a)(1) of the ESA. These include:

A. The present or threatened destruction, modification, or curtailment of its habitat or range;
B. Overutilization for commercial, recreational, scientific, or educational purposes;
C. Disease or predation;
D. The inadequacy of existing regulatory mechanisms; and
E. Other natural or manmade factors affecting its continued existence.

Recovery criteria in this Revised Recovery Plan represent our best assessment of the conditions that may result in a determination in a 5-year review that delisting the spotted owl is warranted, which we would follow by a formal regulatory rule-making process to delist the species. Recovery actions are the Service's recommendations to guide the activities needed to accomplish the recovery criteria. Ultimately, a positive response by spotted owl populations to the recovery actions will mean recovery is occurring. Such a positive response will be measured in accordance with the population-related recovery criterion.

When the Service listed the spotted owl, we identified population decline, small population size, and related demographic conditions as threats. In the current

assessment, these conditions were viewed as results of other threats and not threats *per se*. However, recovery actions are identified here that are intended to address and ameliorate such demographic conditions and address the key threats to the species. Recovery criteria are measurable and achievable goals that we believe will result from implementation of the recovery actions in this Revised Recovery Plan. Achievement of these criteria will take time and is intended to be measured over the life of the plan, not on a short-term basis.

**Recovery Criterion 1 - Stable Population Trend:** The overall population trend of spotted owls throughout the range is stable or increasing over 10 years, as measured by a statistically-reliable monitoring effort.

**Recovery Criterion 2 – Adequate Population Distribution:** Spotted owl subpopulations within each province (*i.e.*, recovery unit) (excluding the Willamette Valley Province) achieve viability, as measured by the HexSim population model or some other appropriate quantitative measure.

**Recovery Criterion 3 – Continued Maintenance and Recruitment of Spotted Owl Habitat:** The future range-wide trend in spotted owl nesting, roosting, foraging habitat is stable or increasing throughout the range, from the date of Revised Recovery Plan approval, as measured by effectiveness monitoring efforts or other reliable habitat-monitoring programs.

**Recovery Criterion 4 – Post-delisting Monitoring:** To monitor the continued stability of the recovered spotted owl, a post-delisting monitoring plan has been developed and is ready for implementation within the States of Washington, Oregon, and California (as required by section 4(g)(1) of the ESA).

## Recovery Actions

In this Revised Recovery Plan, we have retained some of the original recovery actions from the 2008 Recovery Plan, introduced some new recovery actions, and revised some from the 2008 Recovery Plan to reflect new information, and updated status, in order to clarify our intent or respond to public comments. Generally, recovery actions follow the order of the listing factors. However, the first recovery action pertaining to implementation of this Revised Recovery Plan and Recovery Actions 2-4, which address Recovery Criterion 1, do not fit into any of the listing factors and so are presented first. The first recovery criterion assesses the spotted owl's population status. The Service believes this criterion is the best way to assess whether the five listing factors—that is, the threats facing the spotted owl—are addressed. For a more complete description of the threats to the spotted owl addressed by these recovery actions, see Appendix B.

## Northern Spotted Owl Recovery Implementation Oversight

This Recovery Action pertains to all listing factors.

- ***Recovery Action 1: For each State, the FWS will designate offices that will coordinate implementation of the spotted owl recovery plan. These offices will work with local and regional partners to best ensure actions taken within that management jurisdiction are meeting the intention of the recovery plan while taking local context and variation into account. The Oregon Fish and Wildlife Office will remain the overall lead for the species and provide technical assistance and oversight to the other FWS offices as needed.*** We have established and lead an interagency and inter-organizational Northern Spotted Owl Implementation Team (NSOIT) designed to help coordinate implementation of this Revised Recovery Plan throughout the range of the species.

## Monitoring and Inventory

These Recovery Actions also pertain to all listing factors.

- ***Recovery Action 2: Continue annual monitoring of the population trend of spotted owls to determine if the population is decreasing, stationary or increasing.*** Monitoring in demographic study areas is currently the primary method to assess the status of populations of spotted owls. Other statistically valid monitoring methods (*i.e.*, analytically robust and representative of the entire province and range) may be possible and could potentially fulfill this recovery action.

- ***Recovery Action 3: Conduct occupancy inventory or predictive modeling needed to determine if Recovery Criteria 1 and 2 have been met.*** It is expected this inventory will begin when it appears the spotted owl is close to meeting Recovery Criterion 1. Modeling techniques have improved recently, so predictive modeling may be part of the methodology for estimating spotted owl occupancy across the range.

### LISTING FACTOR A: THE PRESENT OR THREATENED DESTRUCTION, MODIFICATION, OR CURTAILMENT OF THE SPECIES' HABITAT OR RANGE.

The key threats identified that relate to this listing factor are: (1) loss of habitat and changes in distribution of habitat as a result of past activities and disturbances, due especially to timber harvest and permanent conversion of habitat; and (2) ongoing habitat loss from natural disturbance (especially fire), timber harvest, and permanent conversion of habitat (see Appendix B).

Therefore, this Revised Recovery Plan recommends two basic strategies to address these threats: (1) conserve more occupied habitat and unoccupied high-value habitat; and (2) encourage and initiate active management actions that restore, enhance, and promote development of high value habitat, consistent with broader ecological restoration goals.

- ***Recovery Action 4: Use the habitat modeling process described above and in Appendix C to identify and implement recovery actions and conservation measures that would contribute to spotted owl recovery, including testing the efficacy of various habitat conservation network scenarios at conserving spotted owl habitat. Use the results from this effort to inform decisions concerning the possible development of habitat conservation networks.***

The following discussion provides the background and justification for the various recovery actions that address Listing Factor A. First, it is important to understand the potential changes in spotted owl habitat conditions and landscape ecological processes due to ongoing climate change. These changes are occurring throughout the spotted owl's range but are currently most serious in the drier portions of the range, and they affect both the species' habitat and its distribution. Second, we address emerging scientific principles of forestry science and "ecological forestry," and how forest scientists are trying to manage spotted owl habitat for resiliency and uncertainty in the face of climate change. And third, we discuss how the science of spotted owl recovery can fit within and be compatible with the broader forest ecosystem science and strategies that land managers are applying in order to be make spotted owl conservation efforts sustainable into the future. These strategies differ from moist forests to dry forest, and on Federal land versus private lands. Specific recovery actions are presented in the context of the relevant sections where management issues are discussed.

## Climate Change and Forest Ecosystems

Climate change, combined with effects from past management practices, is exacerbating changes in forest ecosystem processes and dynamics to a greater degree than originally anticipated in the NWFP. This includes patterns of wildfire, insect outbreaks, drought, and disease. Many researchers believe there is a need to manage forests within an increasingly dynamic and unpredictable future that is driven by climate change (Perera *et al.* 2004, Millar *et al.* 2007, Kurz *et al.* 2008, Heyerdahl *et al.* 2008, Blate *et al.* 2009, Kennedy and Wimberly 2009, Krawchuk *et al.* 2009, Littell *et al.* 2008, 2009, 2010, Reinhardt *et al.* 2008, Johnson and Franklin 2009, Mitchell *et al.* 2009, Spies *et al.* 2010a,b). The preponderance of recent scientific research and opinion on climate change has coalesced around several key points concerning temperature, precipitation, wildfire, and insect and disease outbreaks.

## Temperature and Precipitation

In the Pacific Northwest, mean annual temperatures rose 0.8° C (1.5° F) in the 20th century and are expected to continue to warm from 0.1° to 0.6° C (0.2 ° to 1 ° F) per decade (Mote and Salathe 2010). Global climate models project an increase of 1 to 2 percent in annual average precipitation, with some predicting wetter autumns and winters with drier summers (Mote and Salathe 2010). University of Washington researchers (Salathe *et al.* 2009) have developed finer-resolution, regional, predictive climate models that account for local terrain and other factors that affect weather (*e.g.*, snow cover, cloudiness, soil moisture, and circulation patterns) in the Pacific Northwest. These models agree with the global climate models in projecting warmer, drier summers and warmer, wetter autumns and winters for the Pacific Northwest, which will result in diminished snowpack, earlier snowmelt, and an increase in extreme heat waves and precipitation events.

On the cooler, moister west side of the Cascades, the summer water deficit is projected to increase two- to three-fold over current conditions (Littell 2009). East of the Cascade Crest, summer soil deficits may not change as much or may even moderate slightly over current conditions (Elsner *et al.* 2009). Researchers expect some ecosystems to become more water-limited, more sensitive to variability in temperature, and more prone to disturbance (McKenzie *et al.* 2009). There is evidence that the productivity of many high-elevation forests, where low summer temperature and winter snowpack limits the length of the growing season, is increasing in the Pacific Northwest as temperatures rise, potentially increasing the elevation of the tree line (Graumlich *et al.* 1989, Case and Peterson 2009). Conversely, productivity and tree growth in many low-elevation Pacific Northwest forests is likely to decrease due to the longer, warmer summers (Case and Peterson 2009). This may result in a change in species composition or reduction in the acreage of existing low-elevation forests.

## Wildfire

Wildfire size and frequency have been increasing in the dry, fire prone forests of the western U.S. as a result of changing climatic conditions and past management activities (Westerling *et al.* 2006, Heyerdahl *et al.* 2008, Reinhardt *et al.* 2008, Wiedinmyer and Hurteau 2010, Spies *et al.* 2010a), although some researchers have suggested finer scale exceptions to this general pattern (Odion *et al.* 2004, Heyerdahl *et al.* 2008, Krawchuk *et al.* 2009, Hanson *et al.* 2009, 2010). According to Schafer *et al.* (2010), "An increase in fire activity is expected for *all* major forest types in Oregon" (emphasis original), and areas burned by fire in the Pacific Northwest are likely to increase substantially in the coming century (Hessburg *et al.* 2005, 2007, Kennedy and Wimberly 2009, Littell *et al.* 2009, 2010, Shafer *et al.* 2010).

Natural landscape resilience mechanisms have been decoupled by fire exclusion and wildfire suppression activities (Hessburg *et al.* 2005, Moritz *et al.* 2011).

Before the era of management, patchworks of burned and recovering vegetation, caused by mostly small and medium-sized fires, reduced the likelihood of the largest fires, which usually resulted from extreme weather events. Twentieth-century fire suppression eliminated most of these fires, and forest landscapes are now susceptible to large wildfires.

Stand-replacing events and disturbances will speed up ecological "conversions" (*e.g.*, forests to shrublands) (Joyce *et al.* 2008, Blate *et al.* 2009, Littell *et al.* 2010). Dry forests are at greater risk to large scale disturbances (Agee and Skinner 2005, Mitchell *et al.* 2009), but recent research suggests "that large disturbances are likely in west-side forests that have not traditionally been thought of as fire prone," and "it is therefore reasonable to expect increased fire activity" in such forests (Littell *et al.* 2010). Dry forests are treated in greater detail later in this section.

Older forests in the range of the spotted owl are being lost due to fire (Spies *et al.* 2006, 2010b, Ager *et al.* 2007a, Clark 2007, Healey *et al.* 2008, Kennedy and Wimberly 2009, Hanson *et al.* 2009, 2010), especially east of the Cascades and in the Klamath Province. However, some patches of habitat may be more resistant to climate change effects than others. A study on the east side of the Cascade Mountains found that areas of high soil and fuel moisture had historically created fire refugia where late-successional forest persisted longer (Camp *et al.* 1997). These patches were often near streams or valley bottoms, had perched water tables, or were near headwalls where soil moisture was higher. They were also often at higher elevations where total precipitation was higher or on northern aspects of mountains where terrain was shaded longer. Daley *et al.* (2009) found that cold air pooling in some mountain valleys may decouple or shelter the local microclimate from regional climate conditions. These studies imply that some areas on the landscape may resist climate-driven disturbances that may affect spotted owls and their habitat.

## Insect and Disease Outbreaks

Climate change is affecting the location, size and intensity of insect outbreaks, which in turn affect fire and other forest processes (Joyce *et al.* 2008, Kurz *et al.* 2008, Littell *et al.* 2009, 2010, Latta *et al.* 2010, Spies *et al.* 2010a). Warming temperatures have led to mountain pine beetle outbreaks, with large-scale effects in some western forests, including in the eastern Cascades. In warmer winters more mountain pine beetles survive and shorten their generation time, resulting in larger and more severe outbreaks. Drought can heighten the susceptibility of host trees to attack (Littell *et al.* 2010). Littell *et al.* (2010) suggest that the greatest likelihood of mountain pine beetle attack is when conditions are hot and dry combined with a fairly short period of extreme vapor pressure deficit, when trees are most vulnerable. In the future, outbreaks are projected to increase at higher elevations and decrease at lower elevations (Littell *et al.* 2010), with uncertain implications for spotted owls. Littell *et al.* (2010) have projected that the combination of increased tree susceptibility and mountain pine beetle outbreaks could lead to the loss of pine species in the eastern Cascades as early as the 2040s.

Mixed conifer stands in the eastern Cascades, which include pine species, provide den sites and food resources for bushy-tailed woodrats, an important prey species of spotted owls (Lehmkuhl *et al.* 2006a). Warmer winters have also been shown to increase the incidence of Swiss needle cast, a fungal disease in Douglas-fir on the Oregon coast (Manter *et al.* 2005) inhibiting tree growth, and causing severe chlorosis and defoliation. We are uncertain how significantly this will affect spotted owl habitat.

## Effects of Weather and Climate on Spotted Owl Demography

The influence of weather and climate on spotted owl populations was evidenced in northern California (Franklin *et al.* 2000), Oregon, and Washington (Glenn 2009). Climate accounted for 84 and 78 percent of the temporal variation in population change of spotted owls in the Tyee and Oregon Coast Range study areas, respectively (Glenn 2009). Climate and barred owls together accounted for nearly all (~100 percent) of the changes in spotted owl survival in the Oregon Coast Range (Glenn 2009).

Wet, cold weather during the winter or nesting season, particularly the early nesting season, has been shown to negatively affect spotted owl reproduction (Olson *et al.* 2004, Dugger *et al.* 2005), survival (Franklin *et al.* 2000, Olson *et al.* 2004, Glenn 2009), and recruitment (Franklin *et al.* 2000). Cold, wet weather may reduce reproduction and/or survival during the breeding season due to declines or decreased activity in small mammal populations so that less food is available during reproduction when metabolic demands are high (Glenn 2009). Wet, cold springs or intense storms during this time may reduce the time it takes for an adult bird to starve (Franklin *et al.* 2000). Cold, wet weather may also inhibit the male spotted owl's ability to bring food to incubating females or nestlings (Franklin *et al.* 2000). Cold, wet nesting seasons may increase the mortality of nestlings due to chilling (Franklin *et al.* 2000) and reduce the number of young fledged per pair per year (Franklin *et al.* 2000, Glenn 2009). Wet, cold weather may decrease survival of dispersing juveniles during their first winter thereby reducing recruitment (Franklin *et al.* 2000).

Drought or hot temperatures during the previous summer have also reduced spotted owl recruitment and survival (Franklin *et al.* 2000, Glenn 2009). Drier, warmer summers and drought conditions during the growing season strongly influence primary production in forests, food availability, and the population sizes of small mammals (Glenn 2009). Northern flying squirrels, for example, forage primarily on ectomycorrhizal fungi (truffles), many of which grow better under mesic, or moist, conditions (Lehmkuhl *et al.* 2004). Drier, warmer summers, or the high-intensity fires, which such conditions support, may change the range or availability of these fungi, affecting northern flying squirrels and the spotted owls that prey on them. Periods of drought are associated with declines in annual survival rates for other raptors due to a presumed decrease in prey availability (Glenn 2009).

Survival, recruitment, and reproduction increased with precipitation in the late spring or summer (Olson *et al.* 2004, Glenn 2009). Olson *et al.* (2004) found that while survival decreased with early-nesting season precipitation, it increased with late-nesting season precipitation. This is probably due to reducing the potential for drought to occur.

In addition to effects on habitat, the heat itself may have physiological effects on spotted owls. Weathers *et al.* (2001) suggest California spotted owls (*Strix occidentalis occidentalis*) are less heat-tolerant than other owls responding to temperatures of 30 to 34 º C (86 º– 93 º F) with increased breathing rates, fluffing of feathers, and wing drooping. Northern spotted owls in an earlier study (Barrows 1981) showed signs of heat stress at even more modest temperatures of 27 to 31 º C (81 º–88 º F). We have no current information on how this affects survival or reproduction.

The presence of high-quality habitat appears to buffer the negative effects of cold, wet springs and winters on survival of spotted owls as well as ameliorate the effects of heat. High-quality spotted owl habitat was defined in a northern California study area as a mature or old growth core within a mosaic of different seral stages (Franklin *et al.* 2000). The high-quality habitat might help maintain a stable prey base, thereby reducing the cost of foraging during the early breeding season when energetic needs are high (Carey *et al.* 1992, Franklin *et al.* 2000).

### Barred Owls, Spotted Owls, and Climate Change

Although the scientific literature has explored the link between climate change and the invasion by barred owls, changing climate alone is unlikely to have caused the invasion (Livezey 2009b). In general, climate change can increase the success of introduced or invasive species in colonizing new territory (Dale *et al.* 2001). Invasive animal species are more likely to be generalists, such as the barred owl, than specialists, such as the spotted owl and adapt more successfully to a new climate than natives (Dukes and Mooney 1999).

### Implications for Spotted Owl Conservation

While a change in forest composition or extent is likely as the result of climate change, the rate of that change is uncertain. In forests with long-lived dominant tree species, mature individuals can survive these stresses, so direct effects of climate on forest composition and structure would most likely occur over a longer time scale (100 to 500 years) in some areas than disturbances such as wildfire or insect outbreaks (25 to 100 years)(McKenzie *et al.* 2009). Some changes appear to be already occurring. Regional warming and consequent drought stress appear to be the most likely drivers of an increase in the mortality rate of trees in recent decades in the western United States. The increase was evident across regions (Pacific Northwest, California), elevations (*i.e.*, topography), tree size, type of trees, and fire-return-intervals (van Mantgem *et al.* 2009).

As summarized above, it is clear that ecosystem-level changes are occurring within the spotted owl's forest habitat. Therefore, many of the recovery actions proposed for spotted owls must take into account the uncertainty associated with climate change predictions. There are short-term risks and tradeoffs for long-term benefits when assessing the relative merits of active management (Roloff *et al.* 2005, Spies *et al.* 2006, Carey 2007, Millar *et al.* 2007, Blate *et al.* 2009). As discussed below, landscape-level adaptive management strategies that include active management of forest habitat should be encouraged (Wright and Agee 2004, Lee and Irwin 2005, Carey 2007, Keeton *et al.* 2007, Littell *et al.* 2008). Millar *et al.* (2007) suggest a conceptual framework for managing forested ecosystems in a way that helps ecosystems accommodate changes adaptively. These "adaptation" strategies include: (1) resistance options (to forestall impacts and protect highly valued resources), (2) resilience options (to improve the capacity of ecosystems to return to desired conditions after disturbance), and (3) response options (to facilitate transition of ecosystems from current to new conditions). This framework has value in planning actions to help spotted owls accommodate future climate changes and is discussed in more detail below.

Part of the Service-wide priority for responding to climate change is to conduct species and habitat vulnerability assessments, an analytical tool for determining how climate change will affect a species, habitat, or ecosystem and for developing strategies to safeguard these resources (USFWS 2009). Methodologies have been developed in recent years to conduct vulnerability assessments, some of which may be useful for determining appropriate recovery actions, given the climate change effects on the spotted owl and its habitat (Stein 2010).

Recovery implementation for spotted owls should also, wherever feasible, look for opportunities where managing for spotted owl habitat also meets other societal priorities concerning climate change. For example, the highest densities of forest biomass carbon storage in North America occur in the conifer forests of the Pacific Northwest (Sundquist *et al.* 2009, Keith *et al.* 2010). Older forests with longer rotations may be more effective at sequestering carbon than younger, more intensively managed tree plantations (Schulze *et al.* 2000, Luyssaert 2008), but all forest lands may have value for the purpose of carbon sequestration. Effectiveness in this goal may depend on very specific prescriptions and locales. Preliminary research funded by the Service indicates that forests in Oregon have tremendous potential for carbon sequestration on State forest lands in the Coast Range (Davies *et al*. 2011), and nearby lands likely have similar potential. Likewise, managing for carbon sequestration means it is also necessary to manage forest biomass and the risks of stand replacing wildfire (Canadell and Raupach 2008). As of this writing it is unclear what role, if any, Federal and State forest lands will ultimately play in mitigating climate change, but some policy analysts have begun to frame this issue (see Depro *et al.* 2008).

Therefore, to be consistent with the Secretarial Order as well as other Service initiatives (*e.g.*, Landscape Conservation Cooperatives), we are recommending researchers emphasize ecological and economic overlap between recovery actions for spotted owls and action to mitigation climate change. For example,

more research should be conducted on the relative compatibility or conflict between thinning a forest to reduce fire risk, its impact on long-term spotted owl habitat quality, and the action's mitigation of climate change impacts. Although thinning activity removes carbon from the forest system in the short-term, it may reduce the risk of a subsequent carbon release through fire or disease outbreak, and it also encourages carbon being concentrated in fewer, larger trees that approximate old-growth structure of pre-fire suppression forests (Hurteau *et al.* 2008). The validity of such a concept is not in dispute among mainstream scientists but, as discussed elsewhere in this document, there is significant disagreement regarding where, when, and how to implement such management measures to optimize the potential for positive outcomes.

- ***Recovery Action 5 – Consistent with Executive Order 3226, as amended, the Service will consider, analyze and incorporate as appropriate potential climate change impacts in long-range planning, setting priorities for scientific research and investigations, and/or when making major decisions affecting the spotted owl.***

## Spotted Owls and Ecological Forestry

As documented above, there is a strong scientific consensus that Pacific Northwest forests will be – and already are – undergoing significant changes from current conditions due to past management practices, shifting disturbance patterns, and changing climate influences. There is a variety of scientific opinion regarding the extent to which land managers can manage or positively influence these changes (Millar *et al.* 2007, Reinhardt *et al.* 2008), and how such shifts may affect spotted owls (see, *e.g.*, Hanson *et al.* 2009, 2010 and Spies *et al.* 2010b). To address this uncertainty, we propose applying "active forest management" as part of a spotted owl recovery strategy that includes "ecological forestry and restoration" as described by Franklin *et al.* (2007), Carey (2007), Johnson and Franklin (2009), Long (2009), and Spies *et al.* (2010a), among others. We recommend that land managers consider implementing forest restoration activities where the best available science suggests ecosystems and spotted owls would benefit in the long-term.

We recognize that this recommendation may be controversial. As described below, some forest areas need or would benefit from restoration treatments, whereas others are at less risk or the science is less clear about how to treat certain areas. We make this recommendation to apply ecological forestry and restoration in many parts of the spotted owl's range because:

- Climate change is rapidly altering forest ecosystems within the range of the spotted owl with some unpredictable or potentially undesirable outcomes (Lenihan *et al.* 2008, Littell *et al.* 2010, Shafer *et al.* 2010, Spies *et al.* 2010a);
- The Service, forest managers, and policy makers must take reasonable but proactive steps to conserve forest ecosystems and spotted owls in the face

of past management and future uncertainty (Agee 2002, Carey 2007, Gaines *et al.* 2010); and

- There is a scientific and social consensus emerging that land managers must restore more sustainable (resistant and resilient) ecological processes to forests at various landscape scales (Hessburg *et al.* 2004, Millar *et al.* 2007, Long 2009, Moritz *et al.* 2011).

First, it is worth noting that this recommendation is consistent with a primary goal of the NWFP – the conservation of ecological processes (FEMAT 1993, App. VIII) – and thus should be addressed within the existing planning and adaptive management framework currently in place for Federal lands in the range of the spotted owl. The concept of "conservation of ecological processes" has long been an underlying principle of "ecosystem management" and should be familiar to most land managers in the Pacific Northwest. Ricklefs *et al.* (1984) proposed this concept to include basic ecological cycles on large landscapes, such as the soil formation cycle and the hydrological cycle, with the understanding that fish and wildlife resources are integral to these cycles. That is, conserve the ecological processes and you conserve fish and wildlife. In the 1980s and 1990s, ecosystem management emerged as a dominant theme in managing large landscapes across varied ownerships. Some examples include management of the Greater Yellowstone Ecosystem, the Florida Everglades, the coastal sage scrub of Southern California and the forests of the Pacific Northwest with the NWFP. The NWFP explicitly includes this goal of conserving natural processes (FEMAT 1993, App. VIII).

Natural disturbance processes – wildfire, disease, insect outbreaks and windthrow – are important forces that influence spotted owl habitat. The scientific study and emulation of these processes has emerged as a "dominant paradigm in North American forest management" (Long 2009). Much of this work has occurred in the Pacific Northwest and has direct applicability to forest management in the range of the spotted owl (*e.g.*, Franklin *et al.* 2002, Perera *et al.* 2004, Hessburg *et al.* 2004, Wright and Agee 2004, Nitschke 2005, Drever *et al.* 2006, Noss *et al.* 2006, Carey 2007, Franklin *et al.* 2007, O'Hara 2009, Johnson and Franklin 2009, Long 2009, Odion *et al.* 2010, Swanson *et al.* 2010). A good synopsis of disturbance-based management for forested systems is provided by North and Keeton (2008:366):

> "Disturbance-based forest management is a conceptual approach where the central premise might be summarized as 'manipulation of forest ecosystems should work within the limits established by natural disturbance patterns prior to extensive human alteration of the landscape' (Seymour and Hunter 1999). Although such an objective seems like a simple extension of traditional silviculture, it fundamentally differs from past fine-filter approaches that have manipulated forests for specific objectives such as timber production, water yield, or endangered species habitat. Some critics have argued that this approach leaves managers without clear guidelines because the scale and processes of ecosystems are poorly defined, making it difficult to directly emulate the ecological effects of natural disturbances.

> Disturbance-based management, however, readily acknowledges these uncertainties. It emphasizes a cautious approach, targeted at those specific management objectives, such as provision of complex habitat structures, reduced harvesting impacts, and landscape connectivity that can be achieved. Although this approach will require changes in how management success is evaluated, disturbance-based management is likely to minimize adverse impacts on complex ecological processes that knit together the forest landscape."

The Service continues to recommend that active forest management and disturbance-based principles be applied throughout the range of the spotted owl with the goal of maintaining or restoring forest ecosystem structure, composition and processes so they are sustainable and resilient under current and future climate conditions in order to provide for long-term conservation of the species. The majority of published studies support this general approach for Pacific Northwest forests, although there is some disagreement regarding how best to achieve it. We received widely varying recommendations for meeting this goal from knowledgeable scientists. Most of this variance in opinion is due to the scientific uncertainty in: (1) accurately describing the ecological "reference condition" or the "natural range of variability" in historical ecological processes, such as fire and insect outbreaks across the varied forest landscape within the range of the spotted owl (*e.g.*, see Hessburg *et al.* 2005, and Keane *et al.* 2002, 2009); and (2) confidently predicting future ecological outcomes on this landscape due to rapid, climate-driven changes in these natural processes, with little precedent in the historical (or prehistoric) record (Drever *et al.* 2006, Millar *et al.* 2007, Long 2009, Littell *et al.* 2010).

These are very real problems that should be addressed with more research (Strittholt *et al.* 2006, Kennedy and Wimberly 2009). In the meantime, addressing this uncertainty in a careful but active manner is the challenge of this Revised Recovery Plan and of forest management in general. The Service agrees with those climate scientists and forest researchers who propose that decision makers must deploy a suite of reactive and proactive approaches to cope with the impacts of climate change on forest lands, while taking into account both short- and long-term timeframes and differing landscape scales (Millar *et al.* 2007, Joyce *et al.* 2008, Reinhardt *et al.* 2008, Blate *et al.* 2009, Gaines *et al.* 2010, Spies *et al.* 2010a, Moritz *et al.* 2011). This strategy should incorporate the concept of "adaptation" into forest management decisions (Drever *et al.* 2006, Joyce *et al.* 2008, Long 2009, Littell *et al.* 2010). Adaptation options include: (1) resisting change; (2) promoting resilience to change; and (3) allowing forest ecosystems to respond to change (Millar *et al.* 2007, Joyce *et al.* 2008, Blate *et al.* 2009, Littell *et al.* 2010).

Resistance strategies are usually deployed to protect high-value resources, such as human structures or very rare habitats. They can be expensive and labor intensive, and include actions such as fire suppression across large and rugged landscapes. Resilience-enhancing adaptations include managing within the bounds of natural disturbance processes by emulating these processes through prescriptive actions (Peterson *et al.* 1998, Franklin *et al.* 2002, Drever *et al.* 2006,

Joyce *et al.* 2008). This approach will likely lead to the restoration and maintenance of forest ecosystems which are resilient to a wide range of environmental challenges or scenarios (Long 2009). Allowing forest ecosystems to change as resilience thresholds are crossed means minimizing dramatic and abrupt transitions from one ecosystem condition to another (*e.g.*, forest to shrubland), thereby also minimizing disruptions to important ecological processes (*e.g.*, species dispersal, hydrological cycle, etc.) (Hessburg *et al.* 2005, Blate *et al.* 2009).

Maintaining or improving ecosystem resilience in the face of climate change should be a fundamental goal of forest land managers (Hessburg *et al.* 2005, Reinhardt *et al.* 2008, Lawler 2009, Littell *et al.* 2010). "Resilient forests are those that not only accommodate gradual changes related to climate but tend to return toward a prior condition after disturbance either naturally or with management assistance" (Millar *et al.* 2007). Managing for resilient forests should also be considered a fundamental recovery goal for spotted owls. Federal land managers should apply ecological forestry principles where long-term spotted owl recovery will benefit, even if short-term impacts to spotted owls may occur (Franklin *et al.* 2006) to improve the resiliency of the landscape in light of threats to spotted owl habitat from climate change and other disturbances. For example, managers should promote spatial heterogeneity within patches and local and regional landscapes, restore lost species and structural diversity (including hardwoods) within the historical range of variability, and restore ecological processes to historical levels and intensities (Franklin *et al.* 2002, 2007, Drever *et al.* 2006, Long 2009). This includes early-successional ecosystems on some forest sites (Swanson *et al.* 2010, Perry *et al.* 2011). Some of these management actions may degrade spotted owl habitat in local areas in the short-term (Franklin *et al.* 2006, Spies *et al.* 2006, 2010a), but may be beneficial to spotted owls in the long-term if they reduce future losses of ecosystem structure or better incorporate future disturbance events to improve overall forest ecosystem resilience to climate change (Roloff *et al.* 2005, Ager *et al.* 2007a, Spies *et al.* 2010a).

Of course, trade-offs that affect spotted owl recovery will need to be assessed on the ground, on a case-by-case basis with careful consideration given to the specific geographical and temporal context of a proposed action. There is no "one right prescription." Specific patch-level prescriptions are impossible to make in this Revised Recovery Plan given the tremendous variety in conditions and land management goals across the species' range. Each forest is unique (Agee 2002), and landscape and site-specific assessments need to be made (Lee and Irwin 2005). Prescriptive management goals to address climate change concerns vary across the spectrum of forest types, landscapes, and ownership (Millar *et al.* 2007). When considering a potential restoration treatment project, it will be necessary for land managers working with the Service and other interested stakeholders to weigh the potential tradeoffs between short-term impacts to spotted owl habitat versus longer-term ecosystem restoration outcomes. While our understanding of short- and long-term effects of ecosystem restoration actions on spotted owls is limited at this time, research on effects of more traditional forest management practices on spotted owls and their prey has

been conducted and is discussed below. These studies provide data that should inform development of restoration projects to develop desired future conditions while best maintaining existing spotted owls on the landscape. In addition, projects with these types of effects on Federal land will undergo section 7 consultation to assess the impact to the spotted owl.

## Effects of Forest Management Practices on Spotted Owls

Before applying ecological forestry principles and implementing the recommendations in this Plan, it is necessary to summarize the scientific understanding of how various forest management practices affect spotted owls. Historically, many of the timber management practices used in the Pacific Northwest have had detrimental consequences for spotted owls. Clearcuts, shelterwoods and heavy commercial thinning operations have typically converted spotted owl habitat to non-habitat. Several peer-reviewed publications (Forsman *et al.* 1984, Zabel *et al.* 1992, Buchanan *et al.*1995, Hicks *et al.* 1999, Meiman *et al.* 2003), three master's theses (Solis 1983, Sisco 1990, King 1993) and a number of reports (Anthony and Wagner 1999, Irwin *et al.* 2005, Irwin *et al.* 2008, Irwin *et al.* 2010) specifically addressed effects of timber harvest (primarily thinning operations) on spotted owls, and results of these studies were summarized by Hansen and Mazurek (2010). In most of these studies, one to two spotted owls were affected by thinning projects, and data on thinning effects were collected incidental to larger research objectives. Furthermore, timber harvest activities in these studies were generally not designed or intended to develop future spotted owl habitat.

Among those studies that reported spotted owl responses to thinning or other timber harvest activities, four studies (Forsman *et al.* 1984, King 1993, Hicks *et al.* 1999, Meiman *et al.* 2003) found spotted owls were displaced by contemporary harvest near the nest or activity center. Based on observations of nine spotted owl territories where harvest occurred during the study, Forsman *et al.* (1984) suggested that negative effects (decreased reproduction, site abandonment) of thinning or selective harvest were most likely associated with higher-intensity thinning, timber harvest close to the nest area and when the affected owl site had low amounts of alternative habitat available. Similarly, Meiman *et al.* (2003) reported that a male spotted owl expanded his home range and shifted foraging and roosting away from a thinning operation located close to the nest tree. Consequently, they recommended harvest operations not be conducted near spotted owl nest sites. While harvest activities tend to decrease use by spotted owls during and immediately following the action, spotted owl use of previously logged forest (selectively logged or thinned) was demonstrated in a number of cases: four of these 12 studies reported nesting attempts, five reported roosting, and nine described foraging activities in stands that had been thinned or selectively logged one to five decades earlier (Hansen and Mazurek 2010). Given the small number of spotted owls studied, the information provided in these studies is insufficient for drawing firm conclusions about the effects of thinning prescriptions on spotted owls.

Another important consideration is the effect of vegetation management on spotted owl prey species, including northern flying squirrels, dusky-footed woodrats, bushy-tailed woodrats and other small mammals. The northern flying squirrel's relationships with forest seral stages, forest structure and land management have been a topic of considerable research and debate. Some studies have found that densities of flying squirrels are highest in old forests (Carey *et al.* 1992, Carey 1995), whereas others have suggested that the species is a generalist with respect to seral stage or stand age (Rosenberg and Anthony 1992, Waters and Zabel 1995, Ransome and Sullivan 1997). Studies of the effects of timber harvest on northern flying squirrels have generally found negative responses to thinning, although results have varied across studies. Several studies have suggested that forest thinning can temporarily (*e.g.*, up to 20 years) reduce the availability of truffles, which are a key food resource for northern flying squirrels and other small mammals on which spotted owls depend (Waters *et al.* 1994, Colgan *et al.* 1999, Luoma *et al.* 2003, Meyer *et al.* 2005). However, studies in British Columbia did not find any significant short-term differences in densities, movements or reproduction of flying squirrels in young, commercially-thinned stands versus unthinned young stands (Ransome and Sullivan 2002, Ransome *et al.* 2004). Carey (2000) found lower abundances of flying squirrels in recently-thinned (within 10 years) stands in Washington than in stands that were clear-cut 50 years prior to the study, with retention of both live and dead trees. He attributed his results to the apparently negative effects of commercial thinning on canopy connectivity, downed wood and truffle communities in the area. Wilson (2010) also reported most thinning is likely to suppress flying squirrel populations for several decades, but the long-term benefits of variable-density thinning for squirrels are likely to be positive. He emphasized that developing the next layer of trees is critical if the goal is to accelerate late-seral conditions and promote prey for spotted owl, and complex structure favorable to squirrels may be achieved sooner in younger stands where there is a shorter vertical distance between the ground and the bottom of the canopy.

Mixed results have also been reported in studies that examined effects of thinning on woodrats. Dusky-footed woodrats occur in a variety of conditions, including both old, structurally complex forests and younger seral stages, and are often associated with streams (Raphael 1987, Carey *et al.* 1992, 1999, Williams *et al.* 1992, Sakai and Noon 1993, Anthony *et al.* 2003, Hamm and Diller 2009). Research has suggested that thinning or associated practices (*e.g.*, burning slash piles) could be detrimental to dusky-footed woodrats if it reduces hardwoods, shrubs or downed wood, yet treatments could ultimately benefit woodrats if they result in growth of shrubs or hardwoods (Williams *et al.* 1992, Innes *et al.* 2007). Bushy-tailed woodrats may be more limited by abiotic features, such as the availability of suitable rocky areas for den sites (Smith 1997) or the presence of streams (Carey *et al.* 1992, 1999). Similar to dusky-footed woodrats, forms of thinning that reduce availability of snags, downed wood or mistletoe could negatively impact bushy-tailed woodrat populations (Lehmkuhl *et al.* 2006a). A study of dusky-footed woodrats in the redwood region of California, however,

did not find an association between abundances of woodrats and different intensities of commercial thinning (Hamm and Diller 2009).

Results from these studies suggest that active management projects should explicitly evaluate the short-term impacts to spotted owls and their prey while considering the long-term ecological benefits of such projects, especially in spotted owl core-use areas. Spotted owl home ranges generally have a greater proportion of older forest within the core-use area and more diverse forest conditions on the periphery of their ranges (Swindle *et al.* 1999). The studies referenced above primarily described effects of commercial timber harvest; management designed under an ecological forestry framework should avoid existing high value habitat, if possible, while meeting long-term restoration goals. Within provincial home ranges but outside core-use areas, opportunities exist to conduct vegetation management to enhance development of late-successional characteristics or meet other restoration goals in a manner compatible with retaining resident spotted owls. Restoration activities conducted near spotted owl sites should first focus on areas of younger forest less likely to be used by spotted owls and less likely to develop late-successional forest characteristics without vegetation management. Vegetation management should be designed to include a mix of disturbed and undisturbed areas, retention of woody debris and development of understory structural diversity to maintain small mammal populations across the landscape.

At regional landscape scales, managers should consider how spotted owls fit into a larger ecological framework. Additional factors including historical disturbance regimes and different forest vegetation communities need to be considered. The following section addresses these regional differences in more detail. As ecological forestry is considered and applied in the Pacific Northwest, forest ecosystem management goals will differ between moist and dry forests, and between northern interior portions of the range versus coastal areas in California (Spies *et al.* 2006, Strittholt *et al.* 2006, Mitchell *et al.* 2009). The following sections provide some principles for land managers to consider in these differing forests within the spotted owl's range.

## Habitat Management in Moist Forests

A primary spotted owl recovery goal of this Revised Recovery Plan for moist forests is to conserve older stands that are either occupied or contain high-value spotted owl habitat; this recovery goal is discussed in greater detail later under Recovery Action 10 and Recovery Action 32. On Federal lands these recommendations apply to reserved and non-reserved land allocations.

Managers of the moist forest landscapes recognize that emulating natural disturbance patterns at large landscape levels will be very difficult (Wimberly *et al.* 2004). In contrast to dry forests, short-term fire risk is generally lower in the moist forests that are the dominant condition on the west side of the Cascade Range, and disturbance-based management for forests and spotted owls here should be different. Silvicultural treatments are generally not needed to

maintain existing old-growth forests on moist sites (Wimberly *et al.* 2004, Johnson and Franklin 2009). Efforts to alter either fuel loading or potential fire behavior in these sites could have undesirable ecological consequences (Johnson and Franklin 2009, Mitchell *et al.* 2009). Potential management in older forests, either for climate-related management or spotted owl recovery, must explicitly weigh the relative pros and cons of such activities.

However, this recommendation should be reassessed regularly as new scientific information emerges regarding climate change. For example, Littell *et al.* (2010) suggest climate-driven fire risk may increase on the west-side in moist forests, and Shafer *et al.* (2010) conclude that fire activity is expected to increases in all forest types in Oregon. Although these model predictions are still highly variable, the recommendations of mainstream climate scientists (Littell *et al.* 2010, Shafer *et al.* 2010) should be incorporated into longer-term planning. Wimberly *et al.* (2004) give some recommendations to consider in the Oregon Coast Range that address historical fire regimes and disturbance patterns.

Even with uncertain model predictions, there are younger or less diverse moist forest areas outside of old-growth stands where active management could promote ecological goals, including spotted owl recovery. The most current evaluations suggest climate change in the Pacific Northwest is affecting processes in addition to wildfire, including insect and disease outbreaks and changes in species composition (Latta *et al.* 2010, Littell *et al.* 2010, Spies *et al.* 2010a). Therefore, ecological forestry and active management in the range of the spotted owl should address issues in addition to wildfire dynamics. For example, where past management practices have decreased age-class diversity and altered the structure of forest patches, targeted vegetation treatments could simultaneously reduce fuel loads and increase canopy and age-class diversity (Franklin *et al.* 2002, 2006, Wimberly *et al.* 2004, Littell *et al.* 2010). Likewise, there may be post-disturbance opportunities to restore more natural, early successional forest conditions that provide more ecological benefits to spotted owls (and other native forest species) than do traditional clearcuts and young, even-aged stands (Swanson *et al.* 2010).

Long-term spotted owl recovery could benefit from forest management where the basic goals are to restore or maintain ecological processes and resilience. Therefore, we recommend application of disturbance-based principles to such decisions (Franklin *et al.* 2002, 2006, 2007, Drever *et al.* 2006, Noon and Blakesley 2006, Carey 2007, Long 2009, Swanson *et al.* 2010). For example, some treatments may accelerate the development of spotted owl nesting habitat (Wimberly *et al.* 2004, Andrews *et al.* 2005), even if it temporarily degrades existing dispersal habitat (Franklin *et al.* 2006). This issue needs more applied research, and land management experiments should target this need. There are areas in moist LSRs where stands average 50 years or older that are uniform and not likely to achieve desired complexity or resilience on their own, yet may develop structural complexity more quickly with treatment (Bailey and Tappeiner 1998, Latham and Tappeiner 2002, Carey 2003). These areas should be considered for restoration treatments designed to encourage development of late-successional structural complexity and promote resilience in the face of expected climate-

driven changes (Johnson and Franklin 2009). Much of this activity can, and should, be carried out in all Federal land classifications consistent with the NWFP Standards and Guidelines. In some cases, it may be appropriate to seek exemptions to the 80-year old threshold for silvicultural activities in LSRs if a clear conclusion can be reached that spotted owl recovery and/or ecosystem restoration goals would be met. Research and monitoring on the specific effects of such treatments on spotted owls and their prey is needed and should evaluate effects on both spotted owl recovery as well as broader forest management goals.

In general, to advance long-term spotted owl recovery and ecosystem restoration in moist forests in the face of climate change and past management practices, we recommend the following principles be applied by land managers:

1. Conserve older stands that have occupied or high-value spotted owl habitat as described in Recovery Actions 10 and 32. On Federal lands this recommendation applies to all land-use allocations outside of Congressionally Reserved Areas.

2. Management emphasis needs to be placed on meeting spotted owl recovery goals and long-term ecosystem restoration and conservation. When there is a conflict between these goals, (*e.g.*, short-term adverse impact but expected long-term benefit), managers should make tradeoffs explicit and seek Service input if necessary. Use a sliding scale to prioritize landscapes (*e.g.*, watersheds, stands, etc.) for treatment.

3. Continue to manage for large, continuous blocks of late-successional forest.

4. Regeneration harvest, if carried out, should apply ecological forestry principles as recommended by Franklin *et al.* (2002, 2007), Drever *et al.* (2006), Johnson and Franklin (2009), Swanson *et al.* (2010), and others cited above.

5. Use pilot projects and applied management to test or demonstrate techniques and principles (Noon and Blakesley 2006). In the near term, to reduce conflict and potential inconsistencies with existing Federal land management plans, locate such pilot projects wherever possible in Matrix and Adaptive Management Areas. However, we continue to recommend that such actions be considered in LSRs if a determination is made that treatments would meet broader ecosystem restoration goals.

- ***Recovery Action 6: In moist forests managed for spotted owl habitat, land managers should implement silvicultural techniques in plantations, overstocked stands and modified younger stands to accelerate the development of structural complexity and biological diversity that will benefit spotted owl recovery.***

Implement LSR treatments per the Standards and Guides of the NWFP. In addition, LSR thinning in plantations older than 80 years of age should occur in cases where long-term beneficial effects to spotted owls will be realized from

enhancing within-stand structural diversity. The treatment should emphasize the retention of the oldest and largest trees in the stands or any trees with characteristics that create stand diversity (*e.g.*, bole and limb deformities) and should focus on structural diversity in the mid- to upper- story layers, but not at the expense of large snags or existing species diversity. Cases where facilitating a thinning operation necessitates felling existing remnant trees over 120 years old should be rare. We recommend the use of fungal inoculation, mechanical methods, or other tools as needed to create snags. The Service is available to participate in local or regional efforts to provide guidance on these sorts of prescriptions. Any LSR thinning in plantations greater than 80 years old, if appropriate, should occur where nesting and roosting habitat is needed within LSRs to bolster spotted owl populations and should be considered within the interagency structure of the Level 1 teams.

Likewise, in areas with regeneration harvest in moist forest Matrix lands, any harvest should be designed using ecological forestry principles that emphasize retention of larger and older trees, snags and downed wood of varying size and decay classes, and live trees with decay and deformities (see Swanson *et al.* 2010). Unlike traditional regeneration harvests, applying these measures retain important habitat features while also encouraging eventual development of late-successional conditions.

## Habitat Management in Dry Forests

Although the dry forest portion of the spotted owl's range hosts a minority of the overall population, management of spotted owl habitat in these drier areas is an extremely complex undertaking. Changing climate conditions, dynamic ecological processes, and a variety of past and current management practices render broad management generalizations impractical. Recommendations for spotted owl recovery in this area also need to be considered alongside other land management goals – sometimes competing, sometimes complimentary – such as fuels management and invasive species control. In some cases, failure to intervene or restore forest conditions may lead to dense stands heavy with fuels and in danger of stand-replacing fires and insect and disease outbreaks. As a consequence, the dry forest discussion below provides substantial detail on spotted owl ecology in such areas, including a more specific treatment of the effects of climate, fire, and insect and disease outbreaks on spotted owl habitat.

In general, we recommend that dynamic, disturbance-prone forests of the eastern Cascades, California Cascades and Klamath Provinces should be actively managed in a way that reconciles the overlapping goals of spotted owl conservation, responding to climate change and restoring dry forest ecological structure, composition and processes, including wildfire and other disturbances (Noss *et al.* 2006, Spies *et al.* 2006, 2010a, Agee and Skinner 2005, Healey *et al.* 2008, Mitchell *et al.* 2009). Vegetation management of fire-prone forests can retain spotted owl habitat on the landscape by altering fire behavior and severity (Reinhardt *et al.* 2008, Haugo *et al.* 2010, Wiedinmyer and Hurteau 2010) and, if carefully and strategically applied, it could be part of a larger disturbance

management regime for landscapes that attempts to reintegrate the relationship between forest vegetation and disturbance regimes, while also anticipating likely shifts in future ecosystem processes due to climate (Gartner *et al.* 2008, Noss *et al.* 2006, Lawler 2009, Mitchell *et al.* 2009, Littell *et al.* 2010, Swanson *et al.* 2010, Moritz *et al.* 2011). Such an approach is more likely to achieve ecologically and socially acceptable outcomes, and could enable transitions to more acceptable disturbance regimes, even if it includes more frequent but less severe wildfires (Allen *et al.* 2002, Wright and Agee 2004, Hessburg *et al.* 2005, 2007, Strittholt *et al.* 2006, Reinhardt *et al.* 2008). Some areas, such as dry portions of the Klamath Province, have a different fire ecology than areas in the East Cascades and may not be subject to the same generalizations (Odion *et al.* 2004, 2010, Skinner *et al.* 2006, Hanson *et al.* 2009, 2010); this should be evaluated at a finer scale by recovery implementation teams and interested land managers.

Specific silvicultural practices that promote forest resilience and that can be applied to various forest types are given by Franklin *et al.* (2002, 2006, 2007), Hessburg *et al.* (2004, 2005, 2007), and Drever *et al.* (2006). Short-term decisions to increase forest ecosystem adaptations to climate-driven drought stresses may include vegetation management around older individual trees to reduce competition for moisture (Wright and Agee 2004, Agee and Skinner 2005, Reinhardt *et al.* 2008, Johnson and Franklin 2009, Haugo *et al.* 2010, Littell *et al.* 2010). Longer-term strategies may include protecting or restoring multiple examples of ecosystems and promoting heterogeneity among and within forest stands with the potential for natural adaptation to future (and unpredictable) climate changes (Hessburg *et al.* 2005, Kennedy and Wimberly 2009, Blate *et al.* 2009). In many areas, fire could be encouraged to perform its ecological role of introducing and maintaining landscape diversity (DellaSala *et al.* 2004, Reinhardt *et al.* 2008, Odion *et al.* 2010), although it may be desirable to manage fire severity or return intervals through vegetation management at various temporal and landscape scales (Agee and Skinner 2005, Haugo *et al.* 2010, Littell *et al.* 2010, Spies *et al.* 2010a, Moritz *et al.* 2011).

There is an ongoing debate, as captured in Hanson *et al.* (2009, 2010) and Spies *et al.* (2010b), regarding the relative merits of active management in dry forest landscapes and the potential positive and negative impacts to spotted owls (Spies *et al.* 2006). This debate focuses on uncertainty and seems to be one of degree rather than fundamental difference in long-term conservation goals. We would like to build on areas of agreement for spotted owl recovery, but we recognize that many of these recommendations are controversial due to political and socio-economic reasons (*e.g.*, see Spies *et al.* 2010a). However, given the need for action in the face of uncertainty (Agee 2002, Roloff *et al.* 2005, Carey 2007, Millar *et al.* 2007, Reinhardt *et al.* 2008, Littel *et al.* 2010, Mote *et al.* 2010, Shafer *et al.* 2010), we continue to recommend that land managers implement a program of landscape-scale, science-based adaptive restoration treatments in disturbance-prone forests that will reconcile the goals of conserving and encouraging spotted owl habitat while better enabling forests to: (1) recover from past management measures, and (2) respond positively to climate change with resilience (Spies *et al.* 2006, 2010a,b, Millar *et al.* 2007, Reinhardt *et al.* 2008, Haugo *et al.* 2010, Keane

*et al.* 2009, North *et al.* 2010, Littell *et al.* 2010, Stephens *et al.* 2010). This should provide more high quality spotted owl habitat sooner and for longer into the future which will greatly benefit spotted owl recovery in the long-term. Several authors provide clear recommendations for how to consider reconciling spotted owl habitat management with vegetation management in the eastern Cascades (Lehmkuhl *et al.* 2007, Buchanan 2009, Gaines *et al.* 2010, USDA 2010).

## Disturbance Regimes of Dry Forests Within the Range of the Spotted Owl

Ecological disturbance regimes derive from complex interactions among vegetation, climate, topography, and other biotic and abiotic factors that vary over space and time. Fire and other disturbances have been fundamentally important to shaping landscape patterns and processes in the dry forest systems (Hessburg *et al.* 2000a, 2005, 2007, Dale *et al.* 2001, Hessburg and Agee 2003, Skinner *et al.* 2006, Skinner and Taylor 2006, Perry *et al.* 2011). Fire regimes have been described for the Eastern Washington Cascades, Eastern Oregon Cascades, California Cascades, and Klamath Provinces (Hessburg *et al.* 2000a, 2005, 2007, Hessburg and Agee 2003, SEI 2008, Skinner *et al.* 2006, Skinner and Taylor 2006, Perry *et al.* 2011), though there is not agreement on some regime descriptions (Hanson *et al.* 2009, 2010, Spies *et al.* 2010b).

Additional research has advanced our understanding of the occurrence of low, mixed, and high-severity fires in dry forest fire regimes typically considered as low severity only (*e.g.,* see Baker *et al.* 2007, Hessburg *et al.* 2007, Beaty and Taylor 2008, Brown *et al.* 2008, Collins and Stephens 2010, Perry *et al.* 2011). In dry forests of the eastern Cascades of Washington, for example, surface-fire dominated mixed severity fires were found to be more prominent historically than previously thought (Hessburg *et al.* 2007), rendering more spatial and temporal variability in landscape patterns of disturbed and recovering vegetation. Kennedy and Wimberly (2009) found similar results for the Deschutes National Forest in the eastern Cascades of Oregon. Consequently, dry forest landscapes historically comprised a complex arrangement of fire regimes and patch sizes (Hessburg *et al.* 2005, 2007, Skinner *et al.* 2006, Skinner and Taylor 2006, Perry *et al.* 2011), creating spatial and temporal patterns and variability in vegetation and fuels that reinforced self-similar patterns (Turner and Romme 1994, Peterson 2002, Hessburg and Agee 2003, Bigler *et al.* 2005, Skinner *et al.* 2006, North and Keeton 2008, Moritz *et al.* 2011). This temporal and spatial variability in vegetation and fuels has been substantially altered by human activities and are key features that must be included in restoring dry forest ecosystems.

## Past Management Actions

Over the past two centuries, Euro-American settlement has substantially transformed the inland northwest of the U.S. Anthropogenic activities that have altered the landscape include timber harvesting, mining, livestock grazing, fur trapping, constructing roads and rail lines, development of towns and

settlements, agricultural conversion, fire suppression and fire exclusion. These activities have so altered the patterns of vegetation and fuels, and subsequent disturbance regimes, that contemporary landscapes no longer function as they did historically (Hessburg *et al.* 2000a, 2005, Hessburg and Agee 2003, Skinner *et al.* 2006, Skinner and Taylor 2006).

Fire exclusion, combined with the removal of fire-tolerant structures (*e.g.,* large, fire-tolerant tree species such as ponderosa pine, western larch, and Douglas-fir), have reduced the resiliency of the landscape to fire and other disturbances, at least in those forest types outside of the wetter, higher severity fire regime types (Agee 1993, Hessburg *et al.* 2000a, Hessburg and Agee 2003). In the eastern Cascades of Washington and Oregon, forest types that historically had understories of grass and shrubs have shifted to shade-tolerant conifer understories which are denser and less tolerant of fire than historic understories. This has resulted in an overall increase in the area of fire-intolerant forest-types at the expense of fire-tolerant forest types (Hessburg *et al.* 2000a, Hessburg and Agee 2003). Additionally, these understories compete with fire-tolerant tree species for limited water, thus exacerbating drought stress on the structural components that will be important in restoring dry forest ecosystems. These understories result in an altered fuel bed that exhibits increased flame length, fireline intensity and rate of spread over historic understories, putting any remnant fire-tolerant structural features at greater risk of loss to fire (Hessburg *et al.* 2000a).

In addition to the stand structure, the spatial distribution of these stands also influences fire activity across the landscape. The spatial distribution of fire intolerant-stands among the fire-tolerant stands has been fundamentally altered through past management. Past management has homogenized the patchy vegetative network and reduced the complexity that was more prevalent during the pre-settlement era (Skinner 1995, Hessburg and Agee 2003, Hessburg *et al.* 2007, Kennedy and Wimberly 2009). Therefore, rather than existing as patches of fire-intolerant vegetation types being spatially separated, they have become more contiguous, and are more prone to conducting fire, insects, and diseases across large swaths of the landscape (Hessburg *et al.* 2005). This homogenized landscape may be altering the size and intensity of today's fires and further altering landscape functionality (*e.g.,* Everett *et al.* 2000). This alteration in the disturbance regime further affects forest structure and composition. Not only do these landscapes not exhibit the structure or function that they historically had (Hessburg and Agee 2003, Naficy *et al.* 2010), the shift from fire and drought-tolerant species to shade-tolerant species is a shift in the opposite direction in terms of forest types that will be most resilient to projected future climates (Haugo *et al.* 2010).

### Projected Effects of Climate Change in Dry Forest Ecosystems

The implications of climate change on dry forest ecosystems are multi-faceted. The effects and interrelationships are complex and not fully understood. A comprehensive treatment of this topic is beyond the scope of the recovery plan.

Instead, we lay out some of the possible implications of climate change on ecosystem structures and processes that are relevant to dry forest management, and restoration and spotted owl recovery.

Mean temperatures have increased in the Pacific Northwest and northern California. Models project an even more substantial increase than what occurred over the twentieth century (Cayan *et al.* 2008, Mote and Salathe 2010). Seasonally, most models predict the greatest increases during the summer rather than winter months (Cayan *et al.* 2008, Mote *et al.* 2010). Regional models that further consider local geographical features show an increased warming above global model predictions. For example, the loss of snowpack in the Cascades is projected to increase temperatures above those projected in the global models, likely due to the increased heat absorption caused by snowpack loss. This results in many areas of the Cascade Range showing greater rates of winter and spring warming, which is expected to hasten the loss of snowpack and further increase drought stress on trees (Salathe *et al.* 2008), as well as lengthen the fire season (Westerling *et al.* 2006).

The magnitude and direction of changes in mean annual precipitation in the Pacific Northwest and northern California are less clear than for temperature (Cayan *et al.* 2008, Westerling and Bryant 2008, Mote and Salathe 2010). This region is located in a transition zone between projected increased precipitation in the southern portion of North America and projected decreased precipitation in the northern part of the continent (Mote and Salathe 2010). Model projections for northern California range from slight increases in precipitation to decreases of 10-20 percent, with no noticeable change in seasonal precipitation (Cayan *et al.* 2008). In the Pacific Northwest, models are ambiguous in their projections of annual precipitation trends. Seasonal predictions are less ambiguous, however, with most predicting increased winter precipitation and decreased summer precipitation (Mote and Salathe 2010), though regional models project local differences (Salathe *et al.* 2008). Even if increases in annual precipitation should occur, summer water deficits in the Pacific Northwest are projected to increase by 2-3 times due to increased temperatures and decreased summer precipitation (Littell *et al.* 2010). Some projections call for decreases in the amount, frequency, and intensity of precipitation in drier parts of the world, including the western U.S., potentially increasing the vulnerability to drought (Sun *et al.* 2007), while in northern California, some models call for a slight increase in the number and magnitude of large precipitation events (Cayan *et al.* 2008). Due to increasing temperatures throughout the west, more precipitation is expected to fall as rain rather than snow, reducing snow accumulation. Snowpacks are already declining (Stewart *et al.* 2005) and showing decreased water content throughout western North America (Mote *et al.* 2005). Warmer temperatures are expected to result in snow continuing to melt earlier than in the past (Mote *et al.* 2005, Cayan *et al.* 2008), further increasing drought stress on dry forests.

Changes to the range and composition of current vegetation species are expected as local climates transform and become more favorable for some species and less favorable for others (van Mantgem *et al.* 2009, Allen *et al.* 2010, Haugo *et al.* 2010, Littell *et al.* 2010, Shafer *et al.* 2010). For example, Littell *et al.* (2010) predict a 32

percent increase in the area of forests in Washington that will be severely water-limited by the 2020s, with further increases of 12 percent by 2040 and another 12 percent by 2080. Specific to the range of the spotted owl, this effect is most likely to occur in the eastern Cascades in the northern part of the state. As a result, shifts in the range of Douglas-fir and several pine species are expected (Littell *et al.* 2010). A statewide analysis of forests in California indicates evergreen forests will decline while mixed evergreen forests will increase under all climate scenarios modeled (Lenihan *et al.* 2008). Total forest cover is expected to increase by 23 percent statewide in California under the cooler and wetter climate scenarios, whereas forest cover is projected to decrease by 3 and 25 percent under the warmer and drier models used (Lenihan *et al.* 2008). Where climate becomes less suitable for tree species, particularly in areas that become drier, these tree species are likely to decline in growth and become more vulnerable to mortality agents such as fire or insects that may result in large-scale mortality (Littell *et al.* 2010).

Increased mortality rates of trees have already been attributed to drought and heat stress caused by increasing temperatures (van Mantgem *et al.* 2009, Allen *et al.* 2010). Mortality is expected to increase further as temperatures warm and drought stress increases, even in systems that are not water limited (Allen *et al.* 2010). Water limitation is expected to increase across a significant portion of the eastern Cascades of Washington (Littell *et al.* 2010). The degree to which trees may succumb to drought stress is not entirely clear, however, when one considers other effects brought on by climate change. The increase in atmospheric $CO_2$ is expected to have a fertilization effect on tree growth, allowing them to more efficiently use water and reduce their susceptibility to drought stress (Huang *et al.* 2007). However, this efficiency may not be sustainable in the long-term (Huang *et al.* 2007, Lindroth 2010). For example, $CO_2$-enhanced growth may diminish over time as other nutrients become limited; specifically, as nitrogen demand and its subsequent storage in plant biomass increase, its availability to plant growth is expected to decrease, resulting in systems becoming nitrogen limited (Huang *et al.* 2007, Lindroth 2010). Others project that warmer temperatures will eventually increase water stress and evaporative demand, regardless of precipitation amount or water use efficiency (Nielson *et al.* 2006, Barber *et al.* 2000).

The effect of changing disturbance regimes such as fire and insects will likely be more abrupt and rapid than the changes in vegetation composition, distribution, and productivity in response to climate change (Littell *et al.* 2010). Interactions among these disturbances can alter forest structure and function more rapidly than what is predicted to occur through modeling of vegetation redistribution or disturbance alone. In periods of rapid climate change during the Holocene, fire was often the catalyst for changing vegetation (Whitlock *et al.* 2003). How climate change affects fire regimes will vary with the energy or water limitations of the varying ecosystems (Littell *et al.* 2009). In energy-limited wildfire regimes (*e.g.,* ecosystems with abundant fuels, such as productive forests), increasing temperatures are likely to substantially increase fire risk, regardless of precipitation; conversely, in moisture-limited regimes (*e.g.,* particularly dry

ecosystems with limited fuels such as grass and shrublands), changes in both temperature and precipitation will influence their fire risk (Westerling and Bryant 2008). Predicting specifics of disturbance processes is difficult not only because of the uncertainties in the climate models, but also the synergistic interactions among disturbance agents (*e.g.,* Simard *et al.* 2011). In addition, there are other variables not easily modeled that will likely affect disturbance processes under future climate scenarios (Fried *et al.* 2004, Spracklen *et al.* 2009, Littell *et al.* 2010). These include changes in vegetation composition and distribution, as well as changes in ignitions caused by changing climate or by human activity. For example, while mountain pine beetle attacks are projected to be more successful, it is not known how changes in the range of beetles and host trees may affect this success. If vegetation range changes occur rapidly as a result of increased fire, a subsequent spatial heterogeneity across the landscape could substantially reduce the risk of beetle outbreaks (Littell *et al.* 2010).

Multi-year climatic patterns tied to sea surface temperatures in the Pacific Ocean have been linked to fire activity within the Pacific Northwest. Specifically, the El Niño-Southern Oscillation (ENSO) results in an alteration of temperature and precipitation patterns that cycle, on average, every four years, though annual cycles occur (Mote *et al.* 2010). The Pacific Decadal Oscillation (PDO) is a manifestation of ENSO which cycles between cool and warm phases every 20-30 years (Mantua *et al.* 1997). Prior to the onset of fire exclusion in the 20th century, increased fire activity has been associated with warm phases of the PDO (Hessl *et al.* 2004, Heyerdahl *et al.* 2008). Gedalof *et al.* (2005), however, found no difference in fire activity in the latter half of the 20th century between warm and cool phases of the PDO, but they did find a relationship with smaller scale annual and inter-annual variability in the PDO. The PDO entered a warm phase in 1977 (Mantua *et al.* 1997), and it may now be reversing into a cooler phase (JPL 2008), or it may be losing its decadal persistence (Mote *et al.* 2010, NOAA 2011). Given past associations between fire activity and PDO, it could be argued that the next several decades will result in a decrease in fire activity in the Pacific Northwest. However, making such an inference of cause and effect should be done with caution (Hessl *et al.* 2004). The onset of fire exclusion in the 20th century may confound associations of fire activity with PDO (Mote *et al.* 1999). Furthermore, our understanding of how ENSO and PDO will respond to climate change and our ability to extrapolate their influence on disturbance regimes is poor (McKenzie *et al.* 2004).

Though there is uncertainty with how climate change may specifically alter fire regimes, McKenzie *et al.* (2004) proposed several inferences that can be made given our understanding of fire-climate interactions and our understanding of vegetation response to fire. The first inference is that warmer and drier summers will produce more frequent and extensive fires. Second is that reduced snowpack and earlier snowmelt will likely extend the time span of moisture deficits in water-limited systems. Finally, drought stress on plants will increase as a result of the drier conditions and longer moisture deficits, increasing their vulnerability to other multiple disturbances such as fire and insects; these disturbances often have a synergistic effect.

Evidence is already accumulating to support some of the inferences made by McKenzie *et al.* (2004). The frequency of large (>400 hectares) wildfires and the total area burned by these fires has substantially increased in the western U.S. (Westerling *et al.* 2006), despite active fire suppression. Westerling *et al.* (2006) links this trend to an increase in spring and summer temperatures and earlier spring snowmelts, both of which can result in earlier and longer fire seasons. Given the link between climate and wildfire activity, the authors underscore the urgency to ecologically restore forests that have undergone substantial alterations from past land uses. Specific to California and the Pacific Northwest, an analysis of wildland fires between 1984-2005 showed a significant trend of increasing average fire size, and what appears to be a trend towards an increasing proportion of area burned as a result of large fires (Schwind 2008). Trends in burn severity were less conclusive.

Various authors have projected increases in fire potential in response to projected climate changes, both globally (*e.g.,* Liu *et al.* 2010) as well as in areas encompassing parts or all of the spotted owl range. Littell *et al.* (2010) predicted for Washington that by the 2080s, there will be two to three times as much area burned as what burned between 1916 and 2006; specific to the forested ecosystems of the eastern Cascades, Littell *et al.* (2010) predict a near doubling by the 2080s of the mean area burned between 1980 and 2006 (from 63,000 to 124,000 ha). Westerling and Bryant (2008) projected a 15-90 percent increase in fire in northern California by 2070-2099. Though unquantified, an increase in fire activity is expected in all forest types in Oregon (Shafer *et al.* 2010). Spracklen *et al.* (2009) projected that Pacific Northwest forests will experience some of the greatest increases in mean annual area burned in the western U.S., with a projected increase of 78% by 2050 over that burned between 1996-2005. Whitlock *et al.* (2003) suggest that fire frequency or severity may increase under climate projections. However, in areas where changing climate is expected to reduce combustible vegetation, fire activity could decrease (Westerling and Bryant 2008, Krawchuk *et al.* 2009).

Frequent and extensive outbreaks of native forest insects, such as bark beetles and spruce budworm, have occurred historically in the western U.S. (*e.g.,* Amman and Cole 1983, Brookes *et al.* 1987, Swetnam and Lynch 1989, Hessburg *et al.* 1994). However, anthropogenic influences through past management and fire suppression have altered the landscape vegetation patterns, subsequently altering the timing, duration and magnitude of outbreaks (Swetnam and Lynch 1989, Hessburg *et al.* 1994). Climate change is predicted to further exacerbate the situation by redistributing forest insects as well as intensifying all aspects of forest insect outbreak behavior (Logan *et al.* 2003). Temperatures drive the life history of insects and determine their geographic range. As highly mobile species living in a warmer world, insects are expected to readily expand their range and invade new habitats (Logan *et al.* 2003). Increased CO2 levels may further favor sap-feeding insect species such as bark beetles (Whittaker 1999). Yet predicting specific responses is difficult because climate relationships with some forest insect outbreaks are poorly understood (*e.g.*, see Swetnam and Lynch 1993 regarding spruce budworm).

Recent bark beetle outbreaks have exceeded the magnitude of outbreaks documented during the prior 125 years in parts of the U.S. (Raffa *et al.* 2008). It appears that human activities have influenced recent increases in bark beetle activity (Logan and Powell 2001, Logan *et al.* 2003). Changing climate, particularly increased temperature and drought, combined with management that has favored continuous, uninterrupted distributions of host tree species (*e.g.*, Douglas-fir and true fir species), tend to foster outbreaks (Hicke and Jenkins 2008, Raffa *et al.* 2008). Unusually hot and dry weather is already responsible for increased insect outbreaks in forests in several North American localities, from pinyon pine in the southwest U.S. (Breshears *et al.* 2005) to lodgepole pine forests in British Columbia where the beetle outbreak is larger than any recorded in Canada (Carroll *et al.* 2004 as cited in Whitehead *et al.* 2006, Taylor *et al.* 2006). In addition, increased stand densities of lodgepole pine have increased their susceptibility to bark beetle outbreaks throughout the western U.S. (Hicke and Jenkins 2008). There is evidence of irruptive thresholds being crossed by insects in Alaska and British Columbia, whereby the outbreak continues in a self-sustaining mode even after the extreme drought conditions that initiated the attack have subsided (Raffa *et al.* 2008). However, not all outbreaks appear to be exceeding known historical magnitudes. In Colorado for example, mountain pine beetle activity does not exceed historical activity levels, although the insects are moving outside of their known historical range and into higher elevation (Romme *et al.* 2006); the authors, however, point out that it is difficult to know if this movement is truly outside of their historical range given the lack of historical data on beetle distributions.

With respect to forest pathogens, Kliejunas *et al.* (2009) summarize the literature on the relationship between climate change and tree diseases in western North America. They note that while there is great uncertainty with how specific pathogens will respond to climate change, general inferences can be made, all of which can vary by ecosystem and specific climate conditions. Similar to forest insects, pathogen distributions are expected to change, including invasion of new areas by nonnative pathogens. The epidemiology of plant diseases is also expected to change, complicating the prediction of disease outbreaks. The rate that pathogens evolve and overcome host resistance may increase in a rapidly changing climate. With increasing temperatures, we should expect an increase in overwintering survival of pathogens, as well as an increase in disease severity. Predicted drought stress on many host species will increase their vulnerability to, and exacerbate the effect of, many pathogens. Finally, with the exception of extremely dry conditions, climate change may alter fungal pathogens that could have a profound change on rates of wood decay, shortening the length of time valuable legacies like down wood can be retained in the ecosystem (Yin 1999).

Interactions between disturbance processes also need to be considered, but are not well understood. For example, the fuel composition created by mountain pine beetle outbreaks in lodgepole pine is thought to facilitate the stand-replacing fires favorable to lodgepole reproduction (Logan and Powell 2001). However, the evidence is mixed as to whether insect mortality increases the risk or severity of fire (Fleming *et al.* 2002, Bebi *et al.* 2003, Hummel and Agee 2003,

Lynch *et al.* 2006, Parker *et al.* 2006, Romme *et al.* 2006, Kulakowski and Veblen 2007, Jenkins *et al.* 2008, Simard *et al.* 2011). Some studies recorded situations where probability or severity of burns was higher in beetle-killed stands than in control stands (Bigler *et al.* 2005, Lynch *et al.* 2006). Others found no difference in severity or probability of fires occurring in beetle-killed stands compared to control stands (Bebi *et al.* 2003, Lynch *et al.* 2006, Kulakowski and Veblen 2007). Furthermore, high-severity fires that did occur were consistent with the typical fire regime of affected forests, even without the insect outbreaks (see Romme *et al.* 2006). Still other research has found that the likelihood of active crown fire was actually reduced in beetle killed stands than in control stands, potentially due to decreases in the canopy fuels caused by beetle mortality (Simard *et al.* 2011). Finally, Bigler *et al.* (2005) observed that while beetle outbreaks may have contributed to fire severity, other contributors such as pre-fire stand structure and composition were more of an influence.

At a minimum, insect outbreaks substantially alter the fuel complex and ultimate vegetative composition within a stand (Jenkins *et al.* 2008), and such alteration can potentially affect fire activity. Insect mortality does more to affect fire behavior than just increase the dead fuel load. The removal of overstory canopy can decrease the surface fuel moistures, alter understories, and allow for greater wind speeds through the stand, which can affect fire behavior. These changes in stand structure and composition may be more influential drivers of fire risk and severity than the actual direct increase in fuels caused by beetle outbreaks (Bigler *et al.* 2005, Lynch *et al.* 2006). These factors change through time and will influence the behavior of fires that enter the stand at any given time. In short, the relationships between insects and fire are complex with no simple, single conclusion that can be drawn (Romme *et al.* 2006).

In summary, the implications of climate change on dry forest ecosystems are broad and multi-faceted. Though models are not all in agreement, it appears likely that there will be at least some level of summer water deficit, even if overall precipitation increases. This increase in water limitation increases the risk of fire activity and creates drought stress on trees, making them more susceptible to insect attacks. Interactions among these disturbances can have synergistic effects. The existing condition of increased stand densities and decreased landscape heterogeneity further exacerbates the vulnerability of these systems to disturbance, as well the potential magnitude and intensity of the event itself, particularly in those fire regimes that were predominately of mixed- and low-severity (Schoennagel *et al.* 2004, Keeton *et al.* 2007). Ecosystem functions that are already altered due to past management will be further altered with projected climate change.

## Effects of Fire on Spotted Owl Habitat

Research on all three spotted owl subspecies indicates variability in the degree to which spotted owls use post-fire sites, depending on fire severity and the function of the site for spotted owls (*i.e.*, nesting, roosting, or foraging). A few studies have looked at spotted owl occupancy of nesting territories and survival

rates in burned areas. In southwest Oregon, lower occupancy and survival rates of northern spotted owls were found in burned areas compared to unburned areas, but the results were confounded by prior management of the area and harvest after the fire (Clark 2007, Clark *et al.* 2011). Jenness *et al.* (2004) found decreased occupancy of Mexican spotted owls in burned areas compared to unburned areas, although the authors considered the relationship statistically weak. Roberts *et al.* (2011) found no difference in occupancy of California spotted owls between burned and unburned areas, although their burned areas were predominately of low and moderate severity. Bond *et al.* (2002) compared survival rates of all three subspecies of spotted owls in burned sites with overall survival estimates recorded in the literature and found them to be similar.

Spotted owl reproduction and nesting have been observed in burned landscapes and in core areas in which some portion was burned by high-severity fire (*i.e.,* fires with typically 70-100% overstory mortality). It is not known whether there is a maximum amount of high severity fire within a nesting core that would preclude nesting of spotted owls, and there have been no long-term studies to determine how long spotted owls may remain in a burned-over area. Specific to the actual nest tree, Bond *et al.* (2009) did not find any of their four nest trees located in a high severity burn. Nest trees, however, have been observed in patches with low to moderate severity burn (Gaines *et al.* 1997, Clark 2007, Bond *et al.* 2009). For spotted owls nesting in burned areas, reproductive rates are generally similar to unburned areas (Gaines *et al.* 1997, Bond *et al.* 2002, Clark 2007).

While spotted owls have been observed roosting in forests experiencing the full range of fire severity, most roosting owls were associated with low or moderate severity burns (Clark 2007, Bond *et al.* 2009). Specifically, Bond *et al.* (2009) found spotted owls selecting low severity burns for roosting and avoiding high severity burns. In addition, roost sites from which stand measurements were taken had high levels of canopy closure (*i.e.,* greater than 60 percent) and a large tree component, regardless of burn severity (Clark 2007, Bond *et al.* 2009). Spotted owls have been observed foraging in forest areas that experienced fire events of all severities, and seemed especially attracted to edges where burned forest met unburned stands (Clark 2007, Bond *et al.* 2009). This is consistent with other observations of spotted owl habitat use in the Klamath Province, where increased edge between old-growth forest and other vegetation types were important habitat components (Franklin *et al.* 2000). Clark (2007) found that spotted owls did not use large patches of high severity burns, and Bevis *et al.* (1997) found spotted owls shifting their use away from areas burned at a higher severity to those burned at a lower severity; however, the results in both studies may be confounded due to post-fire logging that occurred in the burn areas. Bond *et al.* (2009) found owls selecting burned areas, including high-severity burns, over unburned areas for foraging when those areas were within 1.5 kilometers of a nest or roost site. Bond *et al.* (2009) postulated that selecting burned patches over unburned patches for foraging may be due to increased presence of prey, such as the dusky-footed woodrat, a species associated with open stands and increased shrub and herbaceous cover.

It is unknown whether spotted owl selection of high-severity burns for foraging would prevail in that portion of its range where dusky-footed woodrats are not available (eastern Washington Cascades and most of eastern Oregon Cascades). In these areas, northern flying squirrels are the principle prey species (Forsman *et al.* 2001, 2004, Sztukowski and Courtney 2004) and are more closely tied to closed canopy forest (Lehmkuhl *et al.* 2006a, b). It is difficult to tease out the relationship between prey abundance and prey selection by spotted owls, but studies suggest that variability in diet among spotted owls may be due to spatial variation in prey abundance (Forsman *et al.* 2001, 2004, Roberts and van Wagtendonk 2006). The degree that other prey species are available to spotted owls in post-burn areas outside of the range of the dusky-footed woodrat may affect their use of post-fire landscapes in this area.

There is evidence of spotted owls occupying territories that have been burned by fires of all severities. The limited data on spotted owl use of burned areas seems to indicate that different fire severities may provide for different functions. For example, spotted owls appear to select high severity burns for foraging, but avoid roosting or nesting in these sites. However, there are multiple confounding factors and uncertainties in the data on this topic which limit the strength of the conclusions that can be drawn. Few studies occur in areas where post-fire logging has not taken place, which confounds conclusions regarding non-use of burned areas. Studies that looked at habitat use by radio-marked spotted owls either have low sample sizes or suffer from other confounding effects. For example, Clark (2007) had the largest sample size of radio-marked spotted owls (n=26), but interpretation is confounded by prior management history as well as logging that occurred in the burned area post-fire. The largest sample size of radio-marked spotted owls monitored in burned areas that were not harvested post-fire was seven (Bond *et al.* 2009).

There are no long-term studies to look at how spotted owl habitat use of these sites changes through time since the burn; so far, habitat use studies have all occurred within four years of the fire. Survey information on spotted owls is not always adequate to allow rigorous comparison of spotted owl occupancy in the burn area before and after fire. Likewise, when adequate occupancy data is available pre-fire, the fate of spotted owls tied to sites that are deemed unoccupied after fire are often unknown; whether these spotted owls died in the fire, abandoned the area, or shifted their use to alternate sites within or adjacent to the burned area is rarely known. It is not clear whether spotted owls outside the range of the dusky-footed woodrat, a species tied to habitats consistent with the early seral conditions created by fire, would show similar use of burned areas as those spotted owls in areas where this prey species is available. Finally, we have a poor understanding of how spotted owl occupancy and habitat use are affected by the geographic scale of the disturbance, as well as the spatial arrangement and amount of unburned patches and patches exhibiting different burn severities within a home range. We can conclude that fires are a change agent for spotted owl habitat, but there are still many unknowns regarding how much fire benefits or adversely affects spotted owl habitat.

## Restoring Dry Forest Ecosystems

Dry forest ecosystems exhibit tremendous complexity in structure and process, as well as in the relationships among and within biotic and abiotic components. Historically it was topography and disturbance regimes such as insects and fire that shaped the distribution and composition of vegetation across the landscape, with patches of shade-tolerant and fire-intolerant conifers spatially isolated from one another in the drier forest types. The disturbance regimes, along with the vegetation structure, composition and distribution have been substantially altered since Euro-American settlement. As a consequence, dry forest systems no longer function as they once did (Hessburg *et al.* 2005). There is not agreement on some regime descriptions within the range of the spotted owl (*e.g.*, Hanson *et al.* 2009, 2010, Spies *et al.* 2010b), and our understanding of fire regimes in certain dry forest types is changing (*e.g.*, Hessburg *et al.* 2007, Perry *et al.* 2011). Complicating the matter is the ongoing climate change that will likely increase the stressors on these systems. We may accurately predict some ecosystem changes and not others, but we can be confident that dry forest ecosystems will change in the face of projected climate change. Consequently, there are risks in any management decision we make, whether it be action or no action, active or passive management (Agee and Skinner 2005). Any actions we take should move dry forest systems on a path that will develop and retain the resiliency in the ecosystem to adequately respond to whatever changes do occur. The key to developing that resiliency is to restore the inherent forest structure and composition and to reintegrate the relationship between forest vegetation and the disturbance regimes.

As noted earlier in this document, our intent in this Revised Recovery Plan is to embed spotted owl conservation and recovery within broader dry forest ecosystem restoration efforts to increase the likelihood spotted owl habitat will remain on the landscape longer and develop as part of this fire adapted community instead of being consumed by uncharacteristic wildfires. Herein we borrow from original objectives described in SEI (2008). Our first objective is to develop and maintain adequate spotted owl habitat in the near term to allow spotted owls to persist in the face of threats from barred owl expansion and habitat alterations from fire and other disturbances. The second objective is to restore landscapes that are resilient to fire and other disturbances in the near term, and more resilient to alterations projected to occur with ongoing climate change. The final objective is to restore function of a variety of ecological services provided by late-successional and old forests. It is not our intent, nor do we believe it would be consistent with the above objectives, to do landscape-wide treatments for the purpose of excluding disturbance events such as fires, including high-severity fires. On the contrary, we are looking to support the disturbance regimes inherent to these systems and believe our management should be consistent with the counsel of Hessburg *et al.* (2007:21):

> "Restoring resilient forest ecosystems will necessitate managing for more natural patterns and patch size distributions of forest structure, composition, fuels, and fire regime area, not simply a

> reduction of fuels and thinning of trees to favor low severity fires."

We define resiliency as the "ability of a system to absorb change and variation without flipping into a different state where the variables and processes controlling structure and behavior suddenly change (Holling 1996:734-735)." Key to managing systems for resilience are to keep options open, view events in a regional rather than local context, and to manage for heterogeneity (Holling 1973). Furthermore, managers need to acknowledge our limited understanding and assume that unexpected events will happen. Therefore, managing for resilience does not require the need for precision in predicting future events, "but only a qualitative capacity to devise systems that can absorb and accommodate future events in whatever unexpected form they may take" (Holling 1973:21).

To accommodate future disturbances and restore ecosystem resiliency, we believe it is essential to restore ecosystem structure, composition and processes. Restoring ecosystem structures that provide resiliency will necessitate maintaining and restoring the biological legacies that typically persist through disturbance events and influence the recovery process in the post-disturbance landscape (Franklin *et al.* 2000). With respect to the dry forest landscapes, structural legacies include not only the large trees that tend to be fire tolerant, but the snags and downed wood that were created as a result of the disturbance event. Structural legacies serve valuable functions such as reproductive structures that facilitate plant propagation, modifying microclimates, or improving connectivity through the disturbed area (Franklin *et al.* 2007).

Restoring ecosystem composition that provides resiliency will necessitate managing for vegetative heterogeneity both within and among stands. Compositional, as well as structural heterogeneity, are influenced by tree growth and decline, competition among plants and the resulting mortality, as well as small-scale disturbances (Franklin *et al.* 2002, 2007). Heterogeneity in the patterns of vegetation composition and structure are key features of resilient forests (*e.g.,* Stephens *et al.* 2008). Complex arrangements and spatial patterns of vegetation produce a similar variability in fire behavior and effect, maintaining ecosystem heterogeneity (Stephens *et al.* 2010).

Restoring ecosystem processes that provide resiliency will aid in developing the vegetation structures, composition, patterns, and distributions advocated above. This would include managing for high-severity disturbance events in the appropriate landscape context. High severity fires, for example, provide valuable habitat for fire-dependent species (*e.g.,* Hutto 2008), as well as important seral conditions that contribute to biodiversity (Swanson *et al.* 2010). Conversely, specific locations on the landscape may be identified where it is desirable to manage the vegetation so that fire severity is reduced (*e.g.,* in wildland urban interface or in areas where human activities have increased available fuel (see Odion *et al.* 2004), or in areas where it is desirable to reduce the risk to valued structural legacies).

We believe restoring ecosystem processes will contribute to developing and maintaining ecosystem structure and heterogeneity, increasing the resiliency to disturbance events and ongoing climate change (Schoennagel *et al.* 2004, Fettig *et al.* 2007, Hessburg *et al.* 2007, Klenner *et al.* 2008, Stephens *et al.* 2008, 2010). Restoring these features would further allow the disturbance processes to play their inherent role in maintaining these features (Noss *et al.* 2006). The following treatment principles were derived from multiple sources (SEI 2008, Gaines *et al.* 2010, Hanson *et al.* 2010). We believe them to be consistent with the stated objectives above, and will be important to accommodating future disturbances and restoring ecosystem resiliency. These principles should be part of any dry forest restoration treatment:

1. Emphasize vegetation management treatments outside of spotted owl core areas or high value habitat where consistent with overall landscape project goals. The proportion of Federal land in the dry forest provinces that is currently spotted owl habitat ranges from 18 percent in the Eastern Washington Cascades to 42 percent in the Oregon Klamath Province (Davis and Lint 2005, Davis and Dugger in press). Thus, there are many opportunities to restore ecosystem components in areas that will have little direct effects on spotted owls. Where treatments will occur within spotted owl core areas or high value habitat, we recommend monitoring owl response to treatments or apply treatments as part of an adaptive management process to improve our understanding of how these activities affect spotted owls.

2. Design and implement restoration treatments at the landscape level. Treatments need to be placed in context with the surrounding landscape to be most effective and to accommodate the inherent disturbance regime (see USDA 2010).

3. Retain and restore key structural components, including large and old trees, large snags and downed logs. Retaining these structural features will conserve habitat, legacy, seed stock, and genetic values. In addition, vegetation management to reduce moisture competition and improve the vigor of these older trees will also be necessary. An emphasis should also be placed on retaining tree species that are fire and drought tolerant in those vegetation types that exhibit fire regimes typically of low or mixed severity or typically dominated by predominately a surface -fires regime. However, older trees likely present before fire exclusion should also be retained, regardless of their fire tolerance.

4. Retain and restore heterogeneity within stands (*i.e.,* manage for fine-scale mosaic within stands). This includes both vertical and horizontal diversity.

5. Retain and restore heterogeneity among stands (*i.e.,* manage for meso-scale mosaics across a landscape). Retain patches of denser, moister forests that are good quality spotted owl habitat, as appropriate, within the landscapes where fire may be more frequent but less severe, consistent with historic variability or modeled future variability, and

where its occurrence maintains and provides for desired levels of species and structural diversity.

6. Manage roads to address fire risk.
7. Use wildfires to meet vegetation management objectives where appropriate.

Some form of vegetation management will be necessary to address many of the restoration principles described above. This can be done through a variety of methods, including mechanical removal such as thinning, prescribed burning, or using naturally ignited fires burning within a specified prescription to meet ecological objectives (*i.e.*, wildland fire for resource use). There are risks associated with these treatments in their potential to disturb soils, affect long-term productivity, and increase the risk of exotic plant invasions. Managers need to account for and minimize these risks as they plan and implement restoration treatments. There is also limited information on the effects of these types of treatments on spotted owls; the few studies that have looked at effects of thinning on spotted owls were limited to prescriptions designed to increase stand productivity and decrease stand complexity rather than improve stand structure for spotted owl. To fill this knowledge gap, restoration treatments implemented inside spotted owl core areas or high value habitat should be initiated under a monitoring or adaptive management study to test their effects on spotted owl occupancy, demographic performance and habitat use.

Restoring the large and old fire-tolerant trees and structure requires more than simply retaining them where they are found. In places where fire exclusion or past management has increased the density of surrounding trees, the densities of these smaller trees will need to be reduced to decrease the competition for water and resultant susceptibility to drought stress and insect attack (Thomas *et al.* 2006). Reducing the stand basal area around residual target trees, including large trees present prior to settlement, can be effective in improving the vigor of several tree species (Larsson *et al.* 1983, Feeney *et al.* 1998, Kolb *et al.* 1998, Latham and Tappeiner 2002). This increased vigor helps individual trees to withstand drought stress and better ward off attacks from sap-feeding insects such as bark beetles (Amman and Logan 1998, Schmid and Mata 2005, Fettig *et al.* 2007), but only if done before an outbreak begins (Shore *et al.* 2006, Romme *et al.* 2006). Thinning to improve tree vigor may not be as effective in reducing a stand's susceptibility to defoliating insects, such as western spruce budworm (Muzika and Liebhold 2000), but it may reduce insect densities and ultimate stand damage if the treatment is focused on reducing the tree host species within the stand (Swetnam and Lynch 1993, Su *et al.* 1996).

Mountain pine beetles, at least in lodgepole pine stands, tend to prefer larger trees (Safranyik and Carroll 2006). Their preference for tree size is less clear in ponderosa pine stands (Olsen *et al.* 1996, Negron and Popp 2004). Thus, while thinning lodgepole stands may improve tree vigor and resistance, the larger remnant trees may increase the likelihood of beetle colonization in the stand, particularly once an outbreak begins (Mitchell and Preisler 1991, Preisler and Mitchell 1993). This risk needs to be considered when managing vegetation to

reduce risk of insect attack. Finally, when treating vegetation to reduce susceptibility to insect attack, care needs to be taken to ensure treatments do not increase risk of attack through injury (Jenkins *et al.* 2008).

Vegetation management for the purpose of altering fuels to modify fire behavior at specific locations can be effective (Omi and Martinson 2002, Pollet and Omi 2002, Martinson *et al.* 2003). This assumes, however, that surface fuels generated from the stand treatment were reduced or removed. Otherwise, severities can actually be higher with treatment (Weatherspoon and Skinner 1995, Raymond and Peterson 2005, Prichard *et al.* 2010). In addition, retaining structures that are fire resistant (*e.g.*, retaining the largest trees) will improve effectiveness (Omi and Martinson 2002, Agee and Skinner 2005). Fire severity, however, results from a complex interaction of fuels (including composition and moisture), topography (including slope percent , elevation, and aspect), and fire weather (including wind and temperature). Variations in each of these components and interactions among them will influence fire behavior and its resultant burn severity. Understanding how these components interact within local fire regimes is important to implementing effective restoration treatments. For example, thinning and underburning have resulted in lower fire severities than those observed in untreated stands across a variety of geographical areas and vegetation types (*e.g.,* Pollet and Omi 2002). However, the mixed evergreen forests of the Klamath Province may exhibit stand development pathways that result in different fire susceptibilities (see Perry *et al.* 2011). For example, lower fire severities were observed in stands with longer fire-free periods as well as in untreated stands with closed canopies or with larger, more mature forest conditions, when compared to treated stands (Weatherspoon and Skinner 1995, Odion *et al.* 2004, Alexander *et al.* 2006, Thompson and Spies 2009). Severities of past fires may be a major determinant of future fire severity; for example, in the Klamath Province, stands burned by high severity fires in the previous one or two decades have been observed to reburn at high severity (Odion *et al.* 2010, Thompson *et al.* 2007, Thompson and Spies 2010). Aspect and slope have been tied to fire severity is some areas (*e.g.*, Alexander *et al.* 2006) but not others (*e.g.*, Turner *et al.* 1999). Fire severity within a given patch may be affected by the surrounding landscape (*e.g.* Weatherspoon and Skinner 1995). Finally, extreme fire weather events can overwhelm a stand's resistance to fire, resulting in high severity burns regardless of the topography, fuel condition or prior management (Martinson *et al.* 2003, Skinner *et al.* 2006). Thus, treatments to reduce fire severity need to be strategically located and designed with specific objectives and a clear understanding of how the local landscape responds to the many variables that influence fire severity.

Fuel treatments have other limitations that need to be considered in their application. Treatments require maintenance if they are to remain effective (Agee and Skinner 2005, Reinhardt *et al.* 2008). In addition, treatments that are not maintained may actually result in fire behavior that is more deleterious than expected without treatment (Ager *et al.* 2007b). Finally, given the stochastic nature of fires, without extremely large-scale treatments that may be neither economically nor socially feasible, there is a low probability of fires intercepting

fuel breaks (Rhodes and Baker 2008). However, modeling indicates that strategic placement can improve treatment leverage (*i.e.,* increase the ratio of acres experiencing reduced fire severity to acres treated) (*e.g.,* Loehle 2004, Schmidt *et al.* 2008). Fuel treatments need to be strategically located with clear objectives. They should not be used for the purpose of "fireproofing" the forest. Rather, they should be designed to increase the acceptability of wildfire through reducing fire behavior and severity in local areas, rather than simply to reduce fire occurrence, size, or amount of burned area per se (Reinhardt *et al.* 2008).

Vegetation management treatments that are strategically located in a landscape context are encouraged to restore structural elements, restore heterogeneity within and among stands, and which increase resiliency to future fires and other disturbance events. A necessity of any vegetation management treatment, regardless of its purpose, is to ensure that slash and other residual fuels generated as part of the project are adequately treated so as not to increase fire severity or risk (Agee and Skinner 2005). Treatments should allow us to incorporate future disturbance events as a means to restore and maintain desired ecosystem components and heterogeneity (Noss *et al.* 2006, Reinhardt *et al.* 2008). Prescribed fire may be a means to reintroduce fire as an ecosystem process, but will likely need to be implemented at scales much greater than what has been done in the past to be effective (Baker 1994, Taylor 2000); such a scale may not be socially or politically acceptable at this time (Stephens and Ruth 2005, Schulte *et al.* 2006). Developing wildfire management plans to allow the use of wildfires to meet vegetation management objectives is another tool that the Service encourages.

## Need for Active Management

The characterization of fire risk in the dry forest provinces within the range of the spotted owl has recently been argued in the scientific literature (Hanson *et al.* 2009, 2010, Spies *et al.* 2010b). In short, Hanson *et al.* (2009) concluded that, given the low risk of high-severity fire in these provinces, there is time to conduct needed research to fill key information gaps before committing to a large-scale strategy of active management. We acknowledge the value that some high-severity fires may provide to spotted owls in areas where these effects have been studied, though there are many limitations with the existing data to make strong conclusions. We also agree with the authors that an adaptive management framework should be in place so that we can learn from our management efforts as we go forth, and have included an adaptive management discussion in this plan. However, given the highly altered condition of the existing dry forest ecosystem and the effects of ongoing climate change on the currently compromised functions, we believe restoration of dry forest ecosystem structures and processes must begin now and cannot wait for all key information gaps to be filled.

As an example, the Gotchen Risk Reduction and Restoration Project was designed to reduce fire risk and promote forest health in the Gotchen LSR and the surrounding landscape of the Eastern Washington Cascades on the Gifford

Pinchot National Forest. Forest health in the area had declined dramatically due to a history of selective timber harvest, fire suppression, and widespread tree mortality caused by insects and diseases (USFS 2003). The project included over 2,200 acres of strategic thinning and fuels treatments to reduce the risk of catastrophic wildfire including some degradation of spotted owl habitat deemed necessary to achieve the objectives of the project. Treatment areas included over 1,000 acres of suitable spotted owl habitat, but direct impacts to spotted owls were minimized by avoiding treatments near known spotted owl nest sites.

There are some questions under adaptive management that may be answered within the next several years, the results of which can be applied to future management decisions (*e.g.*, how do spotted owls use areas treated with specific vegetation management prescriptions intended to promote structural features conducive to spotted owl habitat?). Other questions, particularly population-based questions such as how spotted owls respond to disturbance processes, may take decades before clear conclusions can be drawn from those studies. The risk in waiting this long before pursuing restoration activities is a continued loss of valued ecological structures (*e.g.*, large, fire-tolerant trees) to increased drought stress that is projected with future climate change, as well as continued decoupling of vegetation patterns from disturbance processes. In the immediate future, we need to pursue restoration activities that are strategic and that focus on restoring and maintaining ecosystem structure, composition, patterns and processes with an eye towards maintaining resiliency in the face of future climate change.

We also stress this cannot be done successfully without an aggressive adaptive management framework to learn from treatments. Land managers should use pilot projects and active management to test or demonstrate techniques and principles (Noon and Blakesley 2006). In the near term, to reduce conflict and potential inconsistencies with existing Federal land management plans, we recommend locating such projects wherever possible in Matrix and Adaptive Management Areas. However, we continue to recommend that such actions be considered in LSRs as well (Gaines *et al.* 2010). An example of a site-specific plan that could be emulated in other areas is the Okanogan-Wenatchee National Forest Restoration Strategy (USDA 2010). This strategy applies many of the concepts described in this Plan to meet the overlapping goals of spotted owl recovery and ecosystem management.

## Conclusions Regarding Dry Forest Management

Given the complexity of the disturbance regimes in dry forest systems, response of spotted owls to these disturbances, and the projected influence that climate change will play on these regimes, this Revised Recovery Plan recognizes that active management of vegetation within the dry forest landscape is needed to restore ecosystem resiliency consistent with spotted owl conservation objectives. Restoration of forest ecosystems that are resilient to the endemic disturbance regimes and adaptive to impending climate change is a primary goal of any dry forest recovery strategy and needs to include some form of active management to

achieve that objective. Our knowledge is far from complete, and management to restore these systems will be challenging. These knowledge gaps need to be addressed through a well-defined adaptive management approach that reduces biological risk to the spotted owl and provides information to inform future management decisions.

The 2008 Plan called for establishing an interagency, science-based Dry forest Landscape Work Group (DFLWG) as a recovery implementation team to assist the Service in designing a strategy for managing the Klamath Provinces, the Eastern Washington Cascades, Eastern Oregon Cascades, and California Cascades Provinces. Shortly after publication of the 2008 Plan, the Service created another recovery implementation team, the Klamath Province Work Group to address dry forest issues in the Klamath Provinces, leaving the DFLWG to cover the Cascades portion of the dry forest landscape (To more clearly identify the geographic responsibility of the DFLWG, we are renaming it the Dry Cascades Work Group as part of this recovery plan). Both of these work groups were tasked with helping identify landscape-scale approaches to managing these areas based on the restoration of ecosystem processes.

- ***Recovery Action 7: Create an interagency Dry Cascades Work Group that is available to assist land managers in developing and evaluating landscape-level recovery strategies for the Eastern Washington, Eastern Oregon, and California Cascades Provinces, including monitoring and adaptive management actions.***

The DFLWG has been working to evaluate and develop landscape approaches to restoring forest ecosystem structure and processes in support of spotted owl recovery. The work group members represented a broad array of expertise in different technical fields from different geographical areas. Researchers and practitioners comprised the work group, and members brought forward different interpretations of the research in dry forest systems. After this plan is finalized, the Service will appoint a new recovery implementation team, the Dry Cascades Work Group, using a similar diverse array of expertise to continue this work and find areas of agreement upon which a strategy for the dry Cascades provinces can be developed.

This implementation team will be available to help local land management units with the design and development of new prescriptions and treatments for fuel reduction and other dry forest management strategies through training, workshops or other information transfer methods. It may also be asked to develop an integrated strategy for all the Eastern Washington, Eastern Oregon, and California Cascades Provinces. This may include:

1. Recommending relevant research.
2. Standardizing, to the extent possible, new recommendations for prescriptions and treatments for fuel reduction and other dry forest management to facilitate regional comparisons by meta-analysis and to maximize the scientific and management value of studies.

3. Standardizing, to the extent possible, experimental designs to assist with comparability across the region and to ensure statistically valid results.
4. Assisting in the development or evaluation of plans that include landscape specific habitat objectives, treatment strategies, and projected outcomes.
5. Developing monitoring techniques and coordinating effort. Given the uncertainties concerning sustaining spotted owl habitat in dry forest landscapes, monitoring is imperative. Characteristics that may be important to monitor in any dry forest landscape managed for spotted owl habitat include:
    - Total spotted owl habitat area and condition;
    - Dispersal habitat and condition;
    - Effectiveness of spatial isolation on spotted owl habitat clusters;
    - Pattern, amount, and timing of management activities and natural disturbances;
    - Preferred timing of follow-up treatments by area;
    - Patch recruitment potential and timing as replacement spotted owl habitat relative to fledging success; interactions with barred owls; and stand-level prey response to treatments, including habitat elements that support prey (mistletoe, snags, downed wood, forage lichens, truffle abundance);
    - Spotted owl response to habitat and dispersal areas; and
    - Occupancy breeding pairs or single spotted owls

- ***Recovery Action 8: In Eastern Washington, Eastern Oregon and California Cascades Provinces, analyze existing data on spotted owl occupancy pre- and post-fire and establish a consistent database to track owl occupancy response to fires across the dry Cascades provinces.***

Data currently exist that may aid our understanding of spotted owl occupancy of sites after a fire. Most National Forest units in these provinces annually monitor known spotted owl sites for occupancy, and they have accumulated occupancy data sets in burned and unburned areas. Members of the DFLWG have begun compiling and analyzing existing data on occupancy rates of spotted owls in burned and unburned sites, as well as fire extent and severity in the burned sites, to determine how fire influences occupancy rates of spotted owls. We anticipate the DCWG will continue this effort. Existing data on pre- and post-fire vegetation structure is also being analyzed to determine possible connections between pre-fire estimates of fuel loads, fire severity, and subsequent spotted owl occupancy to inform risk analysis efforts. These data should be entered into a database to track future data on spotted owl occupancy and fires. Data collection standards should be established to aid comparison of data among the

provinces to aid in comparison across the provinces, though these standards will be subject to change if methodology improvements become available. This synthesis and analysis will inform land managers about how fuel loads in and adjacent to spotted owl habitats can be managed.

- ***Recovery Action 9: Create an interagency Klamath Province Work Group that is available to assist land managers in developing and evaluating landscape-level recovery strategies for the Oregon and California Klamath physiographic province, which include monitoring and adaptive management actions.***

The KPWG was formed as a recovery implementation team as a result of Recovery Action 8 in the 2008 Recovery Plan, and has been operating since 2008. During the course of several meetings and workshops in 2008 and 2009, the KPWG established a multi-step approach for evaluation of potential alternative conservation strategies for spotted owls in the Klamath Province, a combined view of the Oregon and California Klamath Provinces. The primary steps included: (1) conduct a thorough review of the literature, spotted owl data sets, and spatial information and synthesize into a report describing spotted owl habitat in the Klamath Province, and the role of fire in developing, maintaining, modifying, and removing spotted owl habitat at multiple scales; (2) use spatially-explicit predictive models, developed and validated using current spotted owl location data from the Klamath Province, to identify areas of high-value spotted owl habitat based on forest composition and structure, climate variables, and topographic features; and (3) integrate spotted owl habitat models with models of fire occurrence and severity patterns to identify and prioritize areas for habitat protection, habitat restoration, and fuels treatment. This implementation team will be available to help land management units with the design and development of new prescriptions and treatments for fuel reduction and other dry forest management strategies through training, workshops or other information transfer methods.

## Spotted Owl Habitat Conservation on All Landscapes

This Revised Recovery Plan recommends building on the principles established in the NWFP to conserve and restore more occupied and high-value spotted owl habitat, including increased conservation of habitat on some Federal "Matrix" lands and the evaluation of potential contributions from State and private lands.

This Plan does not propose a new or revised mapped habitat reserve network and continues to recommend reliance upon the LSRs of the NWFP throughout the range of the spotted owl. In addition, the Service sought remand of the 2008 spotted owl critical habitat designation in a recent court case and will consider revisions to the designation, with a final rule to be published by the end of 2012. Critical habitat designation defines and maps those geographical areas essential to the conservation of the species. Particularly in light of the fact that a revised designation based on the latest and best available information is imminent, the

Service believes it is appropriate to use the critical habitat rulemaking process to identify any essential habitat areas for the spotted owl in addition to the LSR system.

Because of the value to spotted owls, it is likely that much of the LSR network that was originally established in the NWFP process will continue to serve as the foundation for the spotted owl recovery on Federal lands. We expect that recommendations made in this Revised Recovery Plan concerning active management of spotted owl habitat, if applied by land managers, will be beneficial to spotted owl conservation and thus may not be considered as having a significant adverse effect on the spotted owl or its critical habitat in the long-term. Final decisions concerning these and other issues will be made as part of the critical habitat revision and section 7 consultation processes.

## Conserving Occupied and High Value Spotted Owl Habitat

The three main threats to the spotted owl are competition from barred owls, past habitat loss, and current habitat loss (USFWS 2008b). Despite the habitat protections of the NWFP, the most recent demographic analysis (Forsman *et al.* 2011) indicates that spotted owl populations are declining on 7 of the 11 active demographic study areas at about 3 percent annually range-wide. Scientific peer reviewers and Forsman *et al*. (2011) recommended that we address this downward demographic trend by protecting known spotted owl sites in addition to the retention of structurally-complex forest habitat.

The Service recommends conserving occupied spotted owl sites throughout the range, especially those containing the habitat conditions to support successful reproduction. This recommendation is especially important in the short-term, until spotted owl population trends improve (Forsman *et al.* 2011).

Conservation of important spotted owl habitat depends on the application of a two-tiered approach to forest land management decisions as follows:

1. Conserve spotted owl sites and high-value spotted owl habitat where possible in addition to Federal conservation blocks to provide additional demographic support to the spotted owl population (see Recovery Action 10, below).
    a. This recommendation includes currently occupied as well as historically occupied sites (collectively "spotted owl sites," see Appendix G: Glossary of Terms).
    b. Work with land managers and spotted owl field scientists to develop prescriptions and approaches to implement this recommendation. At a minimum, this prescription should retain sufficient NRF habitat within the provincial core-use area and within the provincial home range to support breeding, feeding and sheltering.

2. Maintain and restore the older and more structurally complex multi-layered conifer forests on all lands (see Recovery Action 32 under Listing factor E).

It is clear that these two recommendations overlap. It is our hope that their application on Federal, State, and private lands will more effectively address the threats of competition with and displacement by barred owls, as well as the impacts of past and current habitat loss.

This recommendation can be justified at several scales. At the scale of a spotted owl territory, several studies have shown a positive association between spotted owl fitness and spotted owl habitat or a mosaic of habitat types (Franklin *et al.* 2000, Dugger *et al.* 2005, Olson *et al.* 2004). Additionally, Dugger *et al.* (in press) found an inverse relationship between the amount of old forest within the core area and spotted owl extinction rates from territories. At the population scale, Forsman *et al.* (2011) found a positive relationship between recruitment of spotted owls into the overall population and the percent cover of spotted owl NRF habitat within study areas. This multi-scale research suggests retention of spotted owl habitat within spotted owl territories positively affects demographic rates. Because spotted owls on established territories are likely to be more successful if they remain in those locations (Franklin *et al.* 2000), managing to retain spotted owls at existing sites should be the most effective approach to bolstering the demographic contribution of a habitat conservation network and the highest priority for land managers. Retention of long-term occupancy and reproduction at established spotted owl sites will require a coordinated and cooperative effort to craft management approaches tailored to regional, provincial or local conditions.

- ***Recovery Action 10 - Conserve spotted owl sites and high value spotted owl habitat to provide additional demographic support to the spotted owl population.***

For Federal lands, create an interagency scientific team to use the latest and best available habitat modeling information and other data to identify these high value areas. This recovery implementation team will make recommendations for areas to conserve and manage based upon the following criteria and considerations:

- Use of habitat modeling to better identify high value habitat, including consideration of abiotic factors that influence spotted owl usage.

- Use of demographic monitoring and survey data, if available, to inform other measures of value, such as maintaining population distribution in underrepresented areas or to reflect the most current habitat conditions.

- How retention of specific areas may affect probability of persistence of the spotted owl population at the province scale. Use this evaluation to establish “thresholds” for recommendations of which areas to conserve or not.

- Consideration of related barred owl impacts, influence, and management decisions and the likely success of such management actions in those areas.

The intent of this recovery action is to protect, enhance and develop habitat in the quantity and distribution necessary to provide for the long-term recovery of spotted owls. The Service will use the results of this effort to inform subsequent recommendations or decisions regarding the quantity and spatial configuration of habitat necessary to support the recovery of spotted owls. The spatial depiction informed by the habitat modeling efforts will better identify areas where land managers should consider protecting, enhancing and developing habitat to support recovery of spotted owls and, where appropriate, will seek additional public review and comment (*e.g.*, as part of proposed critical habitat). Where the modeling output and/or examination on the ground indicate that forest stands could and should be enhanced or developed through vegetation management activities to improve long-term habitat conditions, or to create improved habitat for spotted owls, larger habitat patches, or increased connectivity between patches, they should generally be encouraged even if they result in short-term impacts to existing spotted owls. However, such a process should occur where a determination is made that these longer term goals outweigh short-term impacts.

## Interim Guidance

In the interim time period while the above team process is formalized and carried out, we recommend the following process be followed.

When planning management activities, Federal and non-federal land managers should work with the Service to prioritize known and historic spotted owl sites for conservation and/or maintenance of existing levels of habitat. The prioritization factors to consider are reproductive status and site condition.

The site conservation priorities for reproductive status are:

- Known sites with reproductive pairs;
- Known sites with pairs;
- Known sites with resident singles; and
- Historic sites with reproductive pairs, pairs, and resident singles, respectively.

The priority for site condition is sites currently with $\geq$40% in the provincial home range (*e.g.*, 1.3 mile radius) and $\geq$50% habitat within the core home range (*e.g.*, 0.5 mile radius). This prioritization provides a guide to evaluate the relative impacts of management actions, and conservation of sites that provide the most support to spotted owl demography.

When implementing this interim process, land managers and the Service should utilize professional judgment as to the best available site-specific data

(collectively across years, if appropriate). These data may be contained in agency databases, land manager files, or other sources. Managers can also decide to conduct surveys to document current status.

Land managers should prioritize vegetation management and silvicultural treatments intended to enhance habitat conditions based on:

- Status as follows:
  - Unoccupied stands
  - Miscellaneous observations sites
  - Historic sites and;
  - Known sites – resident singles;
  - Known sites – resident pairs.
- Known sites with ≤40% in the provincial home range and ≤50% habitat within the core home range
- Ability to affect meaningful structural change in ≤30 years. Land managers should generally avoid activities that would reduce nesting, roosting and foraging habitat within provincial home ranges (*e.g.*, 1.3 mile radius) of reproductive pairs. Activities which address threats from stochastic disturbance (*e.g.*, insect, disease, wildfire, etc.) by restoration action will generally be consistent with the intent of RA 10 even if short-term effects to spotted owls would occur.

In unsurveyed spotted owl habitat, the agencies and the Service should work cooperatively through the Endangered Species Act consultation process to minimize impacts to potential spotted owl sites. It is likely to be most beneficial to address these areas as early in the planning process as possible. Non-federal land managers should seek technical assistance from the FWS as appropriate.

It is not uncommon for an occupied spotted owl site to be unoccupied in subsequent years, only to be re-occupied by the same or different spotted owls two, three or even more years later (Dugger *et al.* 2009). While temporarily unoccupied, these sites provide conservation value to the species by providing habitat that can be used by spotted owls on nearby sites while also providing viable locations on which future pairs or territorial singles can establish territories. Where unique circumstances or questions arise (*e.g.*, multiple activity centers, etc.), the Service is available to assist land managers with applying this recovery action.

As a general rule, forest management activities that are likely to diminish a home range's capability to support spotted owl occupancy, survival and reproduction in the long-term should be discouraged. However, we recognize that land managers have a variety of forest management obligations and that spotted owls may not be the sole driver in these decisions. Here, active forest management may be necessary to maintain or improve ecological conditions. We support projects whose intent is to provide long-term benefits to forest resiliency and restore natural forest dynamic process, when this management is implemented in a landscape context and with carefully applied prescriptions to promote long-term forest health. Examples of active management projects include forest stand

restoration, fire risk reduction, treatment of insect infestations and disease and the restoration of high quality early seral habitat as described by Swanson *et al.* (2010). It is recognized that these projects may have both short and/or long-term effects to spotted owls and that treatments will be designed to minimize impacts as much as possible in keeping with project's intent.

Given natural events such as fire, wind storms, and insect damage, not all habitat-capable lands in a spotted owl home range are likely to contain spotted owl habitat at any one time. The amount and distribution of existing habitat within a home range may determine which management options will have greater or lesser impacts to the ability of spotted owls to occupy and reproduce in those areas. This, in turn, may affect the flexibility for land managers to implement traditional timber harvests while meeting the intent of this recovery action.

In the drier and southern portions of the range, managing for dense older forest mixed with some younger or more structurally diverse stands may also be appropriate (Franklin *et al.* 2000, Olson *et al.* 2004, but see Dugger *et al.* 2005). The Service recognizes there is tremendous variation across the species' range in such habitat conditions, and therefore, we expect to work closely with the BLM, FS and other land managers to define how to best meet the intent of this recommendation.

There is a wide breadth of spotted owl occupancy data throughout the species' range. Where spotted owl occupancy data are unavailable (*e.g*., unsurveyed habitat), land managers have a variety of tools to assist in determining where likely occupied habitat is and how to implement this recovery action, including assumption of occupancy (a common practice during section 7 consultation), surveys, spotted owl modeling results, forest stand data, etc.

Monitoring data, interagency teams, and adaptive management feedback will be useful tools in future revisions of this recovery action and its implementation, and may result in more refined approaches to implementation of this recovery action in the future. In cases where active management is conducted, assessing the effectiveness of treatments within spotted owl home ranges will provide land managers valuable feedback on how to design future projects and approaches within spotted owl home ranges. Land managers and researchers have numerous tools available to assess project efficacy, including spotted owl surveys, habitat mapping, prey analysis and modeling results. When opportunities arise, integration of monitoring in an adaptive management framework would be particularly valuable. The utility of each tool is largely dependent on the pre-project data available for comparison.

Research directly evaluating spotted owl responses to vegetation management including thinning, fuels reduction, and management intended to restore ecosystem functions is needed to address: (1) whether vegetation treatments result in development of desired habitat conditions; (2) whether treatments designed to create spotted owl habitat are used by spotted owls as NRF habitat conditions develop; (3) whether thinning operations designed to create future spotted owl habitat result in site abandonment during or after the operation and

what types of vegetation management operations will allow spotted owls to persist on existing territories (minimize short-term negative effects); and (4) whether fuel reduction treatments can be done in a manner consistent with retaining occupied spotted owl sites and developing future spotted owl habitat on the landscape.

- ***Recovery Action 11: When vegetation management treatments are proposed to restore or enhance habitat for spotted owls (e.g., thinnings, restoration projects, prescribed fire, etc.), consider designing and conducting experiments to better understand how these different actions influence the development of spotted owl habitat, spotted owl prey abundance and distribution, and spotted owl demographic performance at local and regional scales.***

Additional research that identifies both short-term and long-term responses of prey populations (northern flying squirrels, woodrats, and other small mammals) to thinning treatments is also needed. Such forest management experiments should recognize the management activities known to negatively affect spotted owls discussed earlier and seek to expand our understanding of practices that will improve conditions for spotted owls and their prey.

We encourage collaborative efforts among State and Federal agencies, research scientists, and other interested parties where possible. In order to address the questions presented above, both intensive field research projects and larger, retrospective analyses that examine how different forest practices influence development of spotted owl habitat over time are needed.

## Post-fire Logging

Decisions to harvest timber after wildfires often are based on financial considerations, human safety, a desire to modify the composition and resource production of forests, and a desire to "clean up the forest" (Foster and Orwig 2006, Noss and Lindenmayer 2006, Lindenmayer *et al.* 2008). Possible beneficial ecological effects of post-fire timber harvest include: decreased erosion due to placement of debris on the forest floor which intercepts surface water flow; decreased buildup of insect pests due to dead tree removal; decreased magnitude and extent of lethal soil temperatures around burning coarse woody debris; and, in stands where harvest-generated slash is treated, decreased fire risk due to removal of snags (McIver and Starr 2000, Lindenmayer *et al.* 2008, Monsanto and Agee 2008, Peterson *et al.* 2009). However, support is lacking for the contention that reduction of fuels from post-fire harvest reduces the intensity of subsequent fires (McIver and Starr 2000), and planting of trees after post-fire harvest can have the opposite effect. For example, forests in southwest Oregon that were logged and planted after a 1987 fire burned more severely in a 2002 fire than areas that were not logged or planted due, evidently, to high fuel conditions in conifer plantations (Thompson *et al.* 2007).

Detrimental ecological effects of post-fire timber harvest include: increased erosion and sedimentation, especially due to construction of new roads; damage to soils and nutrient-cycling processes due to compaction and displacement of soils; reduction in soil-nutrient levels; removal of snags and, in many cases, live trees (both of which are habitat for spotted owls and their prey); decreased regeneration of trees; shortening in duration of early-successional ecosystems; increased spread of weeds from vehicles; damage to recolonizing vegetation; reduction in hiding cover and downed woody material used by spotted owl prey; altered composition of plant species; increased short-term fire risk when harvest generated slash is not treated and medium-term fire risk due to creation of conifer plantations; reduction in shading; increase in soil and stream temperatures; and alterations of patterns of landscape heterogeneity (Perry *et al.* 1989, McIver and Starr 2000, Beschta *et al.* 2004, Karr *et al.* 2004, Donato *et al.* 2006, Lindenmayer and Noss 2006, Reeves *et al.* 2006, Russell *et al.* 2006, Thompson *et al.* 2007, Lindenmayer *et al.* 2008, Johnson and Franklin 2009, Peterson *et al.* 2009, Swanson *et al.* 2010). Soil damage and erosion are higher with traditional harvesting systems (*e.g.*, tractors) than they are with advanced systems (*e.g.*, helicopters) (Klock 1975, Peterson *et al.* 2009). After the 1988 Yellowstone fire, rates of soil loss were greatest where litter cover was minimal, percent silt content was high, and postfire logging had been conducted (Marston and Haire 1990 in McIver and Starr 2000). Moreover, post-fire timber harvest activities "undermine many of the ecosystem benefits of major disturbances" (Lindenmayer *et al.* 2004:1303) and frequently "ignore important ecological lessons, especially the role of disturbances in diversifying and rejuvenating landscapes" (DellaSala *et al.* 2006:51). To avoid crisis-mode decision-making and to minimize these detrimental effects, ecologically-informed policies based on pre-fire management direction should be developed before fires occur (Lindenmayer *et al.* 2008, Johnson and Franklin 2009).

Results from the three radio-telemetry studies of spotted owls in post-fire landscapes indicate that spotted owls use forest stands that have been burned, but generally do not use stands that have been burned and logged. For example, California spotted owls tracked 4 years post-fire in burned, unlogged stands: (1) had 30 percent of their nonbreeding-season roost locations within the fire's perimeter (Bond *et al.* 2010); (2) selected low-severity burned forests for roosting during the breeding season (Bond *et al.* 2009); and (3) selected low-, medium-, and high-severity burned forests for foraging within 1.5 km of the nest or roost site, with the strongest selection for high-severity burned forest (Bond *et al.* 2009). However, for spotted owls in stands that had been harvested post-fire: (1) infrequent foraging in stands burned with low-, medium-, and high-severity fires was restricted to areas with live trees such as those in riparian areas (Clark 2007), and (2) use shifted away from burned stands during 3 years post-fire (King *et al.* 1998). Comprehensive analyses quantifying how spatial configuration of forest type, burn intensity, and post-fire logging affects spotted owl demographic and occupancy rates will provide critical information for maintaining habitat during fuels-management activities.

Consistent with restoration goals, post-fire management in these areas should promote the development of habitat elements that support spotted owls and their prey, especially those which require the most time to develop or recover (*e.g.*, large trees, snags, downed wood). Such management should include retention of large trees and defective trees, rehabilitation of roads and firelines, and planting of native species (Beschta *et al.* 2004, Hutto 2006, Peterson *et al.* 2009). We anticipate many cases where the best approach to retain these features involves few or no management activities. Forests affected by medium- and low-severity fires are still often used by spotted owls and should be managed accordingly. Many researchers supported the need to maintain habitat for spotted owl prey. For example, Lemkuhl *et al.* (2006) confirmed the importance of maintaining snags, downed wood, canopy cover, and mistletoe to support populations of spotted owl prey species. Gomez *et al.* (2005) noted the importance of fungal sporocarps which were positively associated with large downed wood retained on site post-harvest. Carey *et al.* (1991) and Carey( 1995) noted the importance of at least 10 to 15 percent cover of downed wood to benefit prey. The costs and benefits of post-fire harvest to the development of habitat for spotted owls and their prey should be evaluated by interagency teams (*e.g.*, Level 1 teams) during the consultation process.

- ***Recovery Action 12: In lands where management is focused on development of spotted owl habitat, post-fire silvicultural activities should concentrate on conserving and restoring habitat elements that take a long time to develop (e.g., large trees, medium and large snags, downed wood).*** Examples of areas where we believe this recovery action would greatly benefit future spotted owl habitat development include such fire-affected areas as the Biscuit fire, the Davis fire and the B&B complex.

## Habitat Definitions

While some area-specific definitions of habitat have been developed in parts of the spotted owl's range, identification of existing spotted owl habitat and the management of lands to provide new habitat in the future would benefit greatly from a range-wide set of province-specific definitions of spotted owl habitat (*e.g.,* high-quality, nesting/roosting, foraging, dispersal). Variation in habitat structure and use across the spotted owl's range drives the need for province-specific definitions. The definitions should use forest composition and structure vernacular so that spotted owl habitat can be described in forest-management terms, and may also incorporate spatial and abiotic features that help determine where spotted owls use these types of stands. As part of our habitat modeling process (Appendix C), we solicited information from spotted owl experts on the regional biotic and abiotic factors that dictated where on the landscape spotted owls nested and roosted, and on regional definitions of spotted owl foraging habitat. These data will provide a good starting point for this effort.

- ***Recovery Action 13: Standardize province-specific habitat definitions across the range of the spotted owl using a collaborative process.***

# Tribal Lands

The Service received comments from a number of American Indian Tribes on the draft Revised Recovery Plan indicating concerns that Tribal lands were not recognized separately from other non-federal lands. It was not the Service's intent to imply that Tribal lands are the same as other non-federal lands. The Revised Recovery Plan is not intended to affect the American Indian Tribal governments' rights to manage their lands. We understand Tribal lands are managed in accordance with Tribal goals and objectives, within the framework of applicable laws.

The Service recognizes the special government-to-government relationship between the Federal government of the United States and American Indian Tribal governments derived from the Constitution of the United States, treaties, Supreme Court doctrine, and Federal statutes. The Service acknowledges American Indian Tribal governments as sovereign nations with inherent powers of self-governance.

The Service also recognizes American Indian Tribes have long worked to conserve and monitor spotted owls on their lands. The efforts of many Tribes have contributed to spotted owl conservation and maintained the Tribal cultural values of the spotted owl and its habitat. Many Tribal lands have been managed with a holistic perspective, including reserves and modified silvicultural practices, and therefore can be islands of high quality habitat that support many species as well as healthy ecosystems. The Service is proud of our many positive government-to-government collaborations with American Indian Tribes and the benefits to fish and wildlife conservation.

The Service is committed to engaging in regular and meaningful consultation and collaboration with American Indian Tribal governments to determine what cooperative and voluntary measures Tribes may take to support spotted owl recovery actions and address other recovery needs and opportunities for spotted owls, recognizing the special status of Tribal lands. Consistent with existing laws and policies, and to honor this spirit of consultation and collaboration, the Service will give full consideration to tribal recovery plans, habitat and modeling data, and other conservation efforts.

All of the Service's actions, including our consultation and collaboration, will take place on a government-to-government basis and be consistent with applicable executive and secretarial orders, memoranda, and policies, including Executive Order 13175, "Consultation and Coordination with Indian Tribal Governments" (11/6/2000); Secretarial Order 3206, "American Indian Tribal Rights, Federal-Tribal Responsibilities, and the Endangered Species Act" (6/5/97); Presidential Memorandum (11/5/09); the U.S. Fish and Wildlife Service's Native American Policy (6/28/94), and the Endangered Species Act.

The Service may enter Memoranda of Understanding with Tribes for (a) mutually agreeable species conservation efforts, (b) utilizing Tribal habitat and modeling data regarding the presence of threatened, endangered, or candidate species on Tribal lands, and (c) processes to discuss and resolve matters regarding each government's spotted owl recovery efforts and obligations.

## State and Private Lands

This Revised Recovery Plan acknowledges the role State and private lands can contribute toward recovering the spotted owl. The relative importance of this role to spotted owl recovery should be assessed. In 1994, in its biological opinion on the NWFP, the Service concluded that the NWFP met or exceeded the standards expected for the Federal contribution to recovery of the spotted owl. The Service also concluded in that opinion that overall recovery of the species would be further evaluated to determine recovery needs on non-federal lands. Since 1994, Federal lands have provided the majority of contribution to spotted owl recovery, and in many portions of the range it provides the sole contribution. However, there are portions of the range where habitat on Federal lands are lacking or of low quality or where there is little Federal ownership, and State and private lands may be able to improve recovery potential in key areas.

Given the continued decline of the species, the apparent increase in severity of the threat from barred owls, and information indicating a recent loss of genetic diversity for the species, we recommend conserving occupied sites and unoccupied, high-value spotted owl habitat on State and private lands wherever possible. This recommendation is primarily driven by the concern associated with displacement of spotted owls by barred owls, the need to retain good quality habitat to allow for displaced or recruited spotted owls to reoccupy such habitat, and the need to retain a spotted owl distribution across the range where Federal lands are lacking. Examples of these areas include portions of southwestern Washington, northwestern Oregon (potentially including parts of the Tillamook and Clatsop State Forests), and northeastern California. Because spotted owls on established territories are likely to be more successful if they remain in those locations (Franklin *et al.* 2000), managing to retain spotted owls at existing sites should be the most effective approach to conserving spotted owls. Retention of long-term occupancy and reproduction at established spotted owl sites will require a coordinated and cooperative effort to craft management approaches tailored to regional, provincial or local conditions.

This Revised Recovery Plan acknowledges the important role State and private lands can play toward implementing a coordinated and cooperative effort to recover the spotted owl. The relative importance of this role to spotted owl recovery can be addressed in a variety of ways. Using the rangewide habitat modeling framework will help identify areas where State and private lands can make the best contribution to spotted owl recovery. The Service will continue to work with these landowners to use a variety of voluntary incentives and approaches that will help contribute to spotted owl recovery through protection and development of unoccupied, high-quality habitat.

During the past 20 years, the Service has worked cooperatively with non-federal landowners to minimize negative impacts to spotted owls and to encourage conservation of spotted owl habitat. The Service has worked with a number of different applicants to implement habitat conservation plans (HCPs) and safe harbor agreements (SHAs) that minimize and mitigate impacts or provide for a net conservation benefit. Lands covered under section 10 of the ESA provide for the conservation of key habitat areas and occupied sites.

Although HCPs are not required to advance the recovery of listed species, voluntary recovery actions included in an HCP can promote recovery. These plans generally are designed to provide: (1) high-quality habitat and retain spotted owl sites; or (2) foraging and dispersal opportunities to make important contributions to spotted owl recovery. SHAs must provide a net conservation benefit to the species, while allowing the landowner to return to baseline habitat conditions after a pre-defined period of time. The net conservation benefits are often direct contributions to recovery, even if of a limited temporal nature. We recommend these efforts be continued and expanded in certain portions of the range to retain and recruit spotted owl habitat on State and private lands in areas with a lack of proximal high-quality habitat on Federal lands and where future distribution of spotted owls would improve long-term recovery potential. These areas include, but are not limited to, southwest Washington, northwest Oregon and the north coast of California.

This Revised Recovery Plan also identifies several recovery actions meant to encourage State and private landowners to work voluntarily toward recovery through economic incentives. There are a number of established and emerging incentive-based options that currently exist for non-federal landowners, including conservation banking and carbon sequestration that could provide valuable spotted owl habitat maintenance or restoration. Spotted owls could receive either directed or indirect benefits from ecosystem services market incentives.

- ***Recovery Action 14: Encourage applicants to develop Habitat Conservation Plans and Safe Harbor Agreements that are consistent with the recovery objectives.***

Habitat conservation plans and safe harbor agreements are important tools that non-federal landowners can voluntarily use to assist in the recovery of the spotted owl. On July 27, 2010, the Service finalized a SHA for small woodlot owners in Oregon that will enroll up to 50,000 acres of non-federal lands within the State over a total of 50 years. The primary goal of this SHA is to increase the time between harvests (*i.e.*, defer harvest), and to lightly to moderately thin younger forest stands that are currently not habitat to increase tree diameter size and stand diversity (*e.g.*, species, canopy layers, presence of snags).

- ***Recovery Action 15: The Service will solicit individual recommendations from stakeholders to develop a comprehensive set of tools and business and economic incentives that facilitate creative opportunities for non-federal landowners to engage in management strategies consistent with the recovery objectives.***

Many non-federal landowners and land managers in the region have adjusted their management strategies to emphasize short harvest rotations (*e.g.*, 40 to 50 years) and the processing of comparatively small diameter trees. Incentives should be identified and developed as a means to reward landowners and land managers for implementing "ecological forestry" practices (Franklin *et al.* 2007) designed to recruit and retain higher-quality spotted owl habitat. Such incentives may include extending tax credits for recovery–related activities that are carried out under the Farm Bill to timber production, development of State or Federal subsidies for lands that meet carbon sequestration and habitat development goals, or conservation banks that facilitate mitigation for actions that impact the spotted owl. Many of the emerging ecosystem services incentives could allow landowners to receive financial compensation for providing co-benefits that include growing higher-quality spotted owl habitat. Implementation of the incentives program could be coupled with the SHA process to provide regulatory protection for landowners who create or enhance spotted owl habitat. Aspects of this recovery action may also be implemented more efficiently at the individual state levels as described under Listing Factor D.

- ***Recovery Action 16: Federal, State, and local managers should consider long-term maintenance of local forest management infrastructure as a priority in planning and land management decisions.***

This Revised Recovery Plan documents the need for active forest management and restoration in many parts of the spotted owl's range to meet long-term ecological goals, especially in dry forest areas, which will benefit spotted owl recovery. Meeting this need will require local capability to treat, remove, and process various types of forest biomass under a variety of logistical and economic conditions.

Timber-based economies and communities in the western United States have experienced significant changes during the last half-century. Some declines in workforce can be attributed to changes in environmental regulation at the Federal, State, and local levels during this time period. However, changing domestic and international markets, competition, industry automation, and depleted supply of older timber have all combined to create a sometimes volatile and unpredictable economic environment for local timber-based economies. Many of these economic changes were well underway prior to the listing of the spotted owl and have occurred outside of the spotted owl's range as well (Raettig and Christensen 1999, Conway and Wells 1994, Power 2006).

Several representatives from smaller timber companies and rural communities have stated that the ability to implement forest restoration projects in the future will suffer because of a continued decline in local workforce, expertise, equipment, and milling or processing capacity (Storm 2007, Mason and Lippke 2009, Carrier 2010). The Service recognizes this concern and recommends it be evaluated at the State and local scales.

Although it is beyond the scope of this Revised Plan to address these broader economic issues, it is in the general interest of long-term forest health -- and therefore spotted owl recovery -- to maintain a local ability to implement forest management and restoration projects on public lands. Therefore, it is appropriate for agency land managers to take into account this need when designing, prioritizing, and locating projects. Stewardship contracting by the BLM and the USFS may be applicable to this goal (Newberry 2011).

## LISTING FACTOR B: OVERUTILIZATION FOR COMMERCIAL, SCIENTIFIC, OR EDUCATIONAL PURPOSES

There is no known threat to the spotted owl relative to this listing factor, so no recovery criteria or recovery actions are identified specific to this listing factor.

## LISTING FACTOR C: DISEASE OR PREDATION

Although there is no known imminent threat to the spotted owl from disease or predation (so no recovery criteria are identified specific to this listing factor) it is important to continue to monitor for diseases and pathogens so that appropriate action can be taken if necessary.

# Diseases

### Sudden oak death

Sudden oak death is a potential threat to spotted owl habitat (Courtney *et al.* 2004). This disease is caused by a non-native, recently introduced, fungus-like pathogen, *Phytopthora ramorum*. This pathogen has killed hundreds of thousands of oak and tanoak trees along the California coast (from southern Humboldt County to Monterey County) and hundreds of tanoak trees on the southern Oregon coast (southwestern Curry County) (Goheen *et al.* 2006).

According to Goheen *et al.* (2006:1):

> "The pathogen has a wide host range including Douglas-fir, grand fir, coast redwood, and many other tree and shrub species common in Oregon and Washington forests. Tree mortality, branch and shoot dieback, and leaf spots result from infection depending on host species and location. *Phytopthora ramorum* spreads aerially by wind and wind-driven rain and

> moves within forest canopies and tree tops to stems and shrubs and from understory shrubs to overstory trees. The pathogen survives in infected plant material, litter, soil, and water. It is moved long distances in nursery stock.…State and Federal personnel regularly survey forests and nurseries in the Pacific Northwest to detect the disease."

Due to its potential impact on forest dynamics and alteration of key prey and spotted owl habitat components (*e.g.*, hardwood trees, canopy closure, and nest tree mortality), sudden oak death poses a potential threat to spotted owls, especially in the southern portion of the spotted owl's range (Courtney *et al.* 2004).

### Avian disease

At this time, no avian diseases are significantly affecting spotted owls. It is unknown whether avian diseases such as West Nile virus (WNV), avian flu, or avian malaria (Ishak *et al.* 2008) will significantly affect spotted owls. Carrying out the following monitoring action would alert us if any disease becomes a threat.

- ***Recovery Action 17: Monitor for sudden oak death and avian diseases (e.g., WNV, avian flu, Plasmodium spp.) and address as necessary.***

Monitoring is necessary to assess the degree to which sudden oak death affects spotted owl habitat and whether any avian disease becomes a threat. If one or more pathogens or diseases pose a threat to spotted owls or their habitat, specific responses would need to be developed and implemented.

## Predation

Known predators of spotted owls are limited to great horned owls (Forsman *et al.* 1984), and, possibly, barred owls (Leskiw and Gutiérrez 1998). Other suspected predators include northern goshawks, red-tailed hawks, and other raptors (Courtney *et al.* 2004). Occasional predation of spotted owls by these raptors is not considered to be a threat to spotted owl populations, so no criteria or actions are identified. Actions relative to the threat from barred owls are presented in Listing Factor E.

## LISTING FACTOR D: INADEQUACY OF EXISTING REGULATORY MECHANISMS

One of the original reasons for listing the spotted owl was the inadequacy of the applicable regulatory mechanisms as they existed in 1990. Although there were regulatory mechanisms in place at the time, they offered variable levels of protection to spotted owls and, to a lesser extent, spotted owl habitat. Since 1994, the NWFP has been implemented on Federal lands throughout the range of the

spotted owl. On Federal lands, the Service continues to support the implementation of the NWFP and its associated Standards and Guidelines, as well as the implementation of the recovery actions in this Revised Recovery Plan. This section focuses primarily on the State regulations that cover the approximately 21 million acres of private- and State-owned forest lands in Washington, Oregon and California (see Table III-1).

State and private lands are regulated under various State authorities, and timber harvest within each state is governed by rules that provide varying degrees of protection of spotted owls or their habitat. In Washington, logging practices on State, State trust, and private lands are regulated by the Washington State Department of Natural Resources. In Oregon, the State Forest Practices Act regulates State and private lands. In California, the Forest Practice Rules and timber harvest plan review process on State and private lands substitute for an Environmental Impact Review under the California Environmental Quality Act of 1970. The California Department of Forestry and Fire Protection (CAL FIRE) is responsible for review and approval of timber harvest plans. See below for a more comprehensive treatment of each state.

Since the listing of the spotted owl, there have been some regulatory changes that have reduced the rate of habitat decline on State and private lands. However, in light of the continued decline of the species, the apparent increase in severity of the threat from barred owls, and information indicating a recent loss of genetic diversity for the species, this Revised Recovery Plan identifies a more important recovery role for State and private lands. The Service recommends the States evaluate existing spotted owl conservation efforts and consider changes where appropriate to contribute to recovery goals; specific geographical areas of interest include northeastern California, northwestern Oregon and southwestern Washington. This evaluation should consider the feasibility of restoring and conserving spotted owl habitat on non-federal lands where they can contribute to spotted owl recovery. The Service is available to assist States in evaluating the importance of spotted owl conservation efforts on State and private lands.

In addition, the Service suggests the States evaluate existing regulations affecting spotted owls and make changes where necessary and appropriate to meet recovery goals. We acknowledge the potential economic impacts such changes might have in certain parts of the spotted owl range, and we make several recommendations below to address these concerns.

**Washington.** In 1996, the State Forest Practices Board (Board) adopted Forest Practices Rules (Washington Forest Practices Board 1996, Washington Administrative Code 222) that would contribute to protection of spotted owls on strategic areas of non-federal lands. Adoption of the Forest Practices Rules was based in part on recommendations from a Science Advisory Group that identified important non-federal lands and recommended roles for those lands in spotted owl conservation (Hanson *et al.* 1993, Buchanan *et al.* 1994). The 1996 rule package was developed by a stakeholder policy group and then reviewed, modified, and approved by the Board.

The Board is currently working to develop an updated, long-term strategy to protect the spotted owl and its habitat on private and state forest lands. In 2008, the Forest Practices Board convened a Northern Spotted Owl Policy Working Group (Working Group). The Working Group's consensus recommendations were presented to the Board in February 2010. The Board accepted the Working Group consensus recommendations and directed Washington State Department of Natural Resources to form a Northern Spotted Owl Implementation Team (Washington NSO Implementation Team).

One of the Working Group's recommendations resulted in a rule change that reduces the likelihood that potentially important habitat near a spotted owl site center is lost through timber harvest while the Board completes its long-term conservation strategy. This rule change adds an evaluation by a three-member Spotted Owl Conservation Advisory Group whenever a site center is subject to possible decertification (and therefore loss of regulatory protections provided by the Forest Practices Rules). The purpose of this evaluation is to determine whether habitat at the site center should be maintained, regardless of the site center's occupancy status, while the Board is completing its long-term strategy.

The Board also directed the Washington NSO Implementation Team to develop a work plan, including prioritization, and directed the team to coordinate with the Federal agencies with regard to the Barred Owl control experiments. The Board also directed the Washington NSO Implementation Team to formally convene a technical team to assess spatial and temporal allocation of conservation efforts on non-federal lands using best available science.

- ***Recovery Action 18: The Washington State Forest Practices Board (Board) should use the final recovery plan and the habitat modeling tool to inform the process currently underway to identify areas on non-federal lands in Washington that can make strategic contributions to spotted owl conservation over time. The Service encourages timely completion of the Board's efforts and will be available to assist as necessary.***

**Oregon.** The Oregon Forest Practices Act provides for protection of 70-acre core areas around recently surveyed sites occupied by an adult pair of spotted owls capable of breeding (as determined by protocol surveys), but it does not provide for protection of resident single sites, nor of spotted owl habitat beyond these areas (ODF 2006). The Forest Practices Act does not require spotted owl surveys to identify potential nesting-pair or resident-single sites. The interim protection goals for spotted owl nesting sites initially adopted under the Forest Practices Act at the time of listing have yet to be finalized. There is a process under the Forest Practices Act (*see* Oregon Administrative Rule 629-680) to update resource (*i.e.*, spotted owl) site protection measures. Every two years the Oregon Department of Forestry reports to the Board of Forestry regarding any recommended changes to the resource site protection rules and to identify any research needed to further evaluate the protection levels. This on-going review has not been used to finalize the spotted owl resource site protection rules or to monitor their impact on spotted owls.

- ***Recovery Action 19:  The Service will request the cooperation of Oregon Department of Forestry in a scientific evaluation of: (1) the potential role of State and private lands in Oregon to contribute to spotted owl recovery; and (2) the effectiveness of current Oregon Forest Practices in conserving spotted owl habitat and meeting the recovery goals identified in this Revised Recovery Plan.  Based on this scientific evaluation, the Service will work with the Oregon Department of Forestry and other individual stakeholders to provide specific recommendations for how best to address spotted owl conservation needs on Oregon's non-federal lands.***

Such an analysis is beyond the scope of this Revised Recovery Plan and should be initiated as a cooperative effort between the Service and Oregon Department of Forestry.  Among the issues this evaluation should address are the adequacy of the 70-acre core approach for spotted owl pair nest sites in contributing to recovery needs, an assessment of long-term residency and productivity of spotted owls in these territories, the potential application of the habitat modeling tool (Appendix C) to identify areas of high current or potential recovery value, and the potential application of these results to future land management decisions (*e.g.*, critical habitat revisions, HCPs, etc.).

Similar to the Washington Forest Practices Board's Northern Spotted Owl Policy Working Group, this group should identify voluntary and regulatory incentives that may improve spotted owl conservation on State and private lands, as well as areas where economic and other goals may be achieved while also benefiting spotted owls.  The state-led Washington group provides a strong model for critically examining the contribution of State forestry regulations to spotted owl recovery.

This Oregon effort should focus on the identification of opportunities to address spotted owl recovery needs on State and private lands and an assessment of the various economic and social trade-offs necessary to meet this goal.  Some specific issues this Oregon group should address are:

- potential recommendations to revise Forest Practice regulations, if appropriate and necessary;
- identification of specific opportunities to apply complimentary management goals that meet multiple economic, social, and ecological objectives compatible with spotted owl recovery, such as carbon sequestration, fuels treatment, silviculture, water quality, and recreation;
- coordination between the Oregon Department of Forestry and the Service to receive routine summaries of forest operations; and
- identification of financial and non-regulatory incentives to non-federal land managers that may encourage implementation of recovery actions on these lands (see Recovery Action 15).

**California.** State Forest Practice Rules, which govern timber harvest on private lands, were amended in 1990 to require surveys for spotted owls in nesting, roosting and foraging habitat and to provide habitat protection measures around activity centers (CFPR 2011, 14 CCR§§ 919.9 (a)-(g)). Under the Forest Practice Rules, a timber harvest plan cannot be approved if it is likely to result in incidental take of federally-listed species, unless the take is authorized by a Federal HCP (CFPR 2011, 14 CCR§§ 898.2(d) and (f)). The California Department of Fish and Game (CDFG) initially reviewed all Timber Harvest Plans (THPs) to ensure that take of State- and federally-listed species was not likely to occur. The Service currently provides technical assistance to CAL FIRE in its THP review of federally-listed species.

- ***Recovery Action 20: The Service will request the cooperation of CAL FIRE and individual stakeholders in an evaluation of: (1) the potential recovery role of spotted owl sites and high-quality habitat on non-federal lands in California, and (2) evaluation and implementation of appropriate conservation tools (e.g., carbon sequestration, Habitat Conservation Plans, Safe Harbor Agreements) to assist with supporting spotted owl recovery actions outlined in this Recovery Plan.***

Working with the State and stakeholders in this manner would create an opportunity to identify more locally-specific information to assist with outlining the potential contribution of private lands to spotted owl recovery. This sort of collaboration would also be an appropriate mechanism to identify and create voluntary and regulatory incentives that may improve spotted owl conservation on non-federal lands that integrate with existing State regulatory and incentive programs.

- ***Recovery Action 21: The Service will provide technical assistance to the California Board of Forestry and Fire Protection and CAL FIRE to develop scientifically based and contemporary Forest Practice Rules to provide for the breeding, feeding and sheltering of spotted owls.***

Currently, the State of California considers it a crime to “take, possess, or destroy” birds of prey, including all owl species (California Fish and Game Code: CA FISH & G § 3500 – 3857). While some barred owl removal has occurred in California forest lands under special permits, this statute could hinder the ability to reduce the effects of barred owls on spotted owls in the southern portion of the range.

- ***Recovery Action 22: If barred owl removal is determined to be effective, work with the State of California to explore options for managing barred owls using lethal means.***

**Table III-1.** Summary of the forestry rules that provide spotted owl protections for California, Oregon and Washington

| State | NSO Surveys Required | Habitat Requirements | | | | Noise Disturbance Restrictions | | | NSO Forest Rules last updated | Exceptions |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Which spotted owl sites | Size-Location | Habitat | Duration | Zone size | Duration | Restricted Disturbance Includes | | |
| California[1] | Yes | All | Within 0.7–1.3 miles of center | Within 500 ft. of nest timber operations limited during breeding season and must retain functional nesting habitat[2] | All year as long as determined by CAL FIRE to be a site | 500 ft. | Breeding season[3] | All timber harvest operations except planting and surveying | 2009 – allowed designation of independent biological consultants to fulfill evaluation role for likelihood of take | CFPRs allow for deviations with FWS review and other sec. 7 and 10 |
| | | | | 500-1000 ft. retain functional roosting habitat[2] | | | | | | |
| | | | | 500 acres spotted owl habitat in 0.7 -mile radius | | | | | | |
| | | | | 1336 acres spotted owl habitat in 1.3- mile radius | | | | | | |
| Oregon | No | All | Nest site[4] is within 500 ft. of timber operations | 70-acre no cut Core around nest with the outer edge of the Core no less than 300 ft. distance from the nest | Life of circle | 0.25 mile | Critical period[5] | Timber operations except log hauling, reforestation, road maintenance, research and monitoring, ground application of chemicals, aerial applications that do not require multiple passes, and burning | 2006 | |
| Washington | No | SOSEA | Within 0.7 miles of site center | retain all suitable habitat [6,7] | Life of circle | 0.25 mile | Nesting season[8] | Felling and bucking, yarding, slash disposal, prescribed burning, road construction, and other such activities (operation of heavy equipment and blasting) | 1996 | For landowners whose forest land ownership within the SOSEA is ≤500 acres and where the activity is |
| | | | Within home range of 1.8-2.7 mile radius | retain 40% of suitable habitat [6,7] | | | | | | |
| | | Non-SOSEA | 70 acres around known nest site | retain best 70 acres[7] | Nesting season[8] only | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | >0.7 mile of the NSO site center and sec. 7, 10 and some State planning regulations |

1. California Forest Practice Rules (CFPRs) rely on the Service's Guidelines as presented here.
2. Nest-Roost habitat in California is generally defined as 60-90% canopy closure, multi-layered/species canopy with trees >30 inches diameter, trees with deformities, woody debris on ground and open space below canopy to allow spotted owls to fly.
3. Breeding season for Coastal California is defined as February 1-July 30, Interior as February 1-August 31.
4. Nest site requires a pair of spotted owls.
5. The critical period in Oregon is defined as March 30 to September 30.
6. Suitable habitat in Washington is defined as: forest stands which meet the description of old forest habitat, sub-mature habitat or young forest marginal habitat per Washington Forest Practices Regulations (Washington Forest Practices Board 1996).
7. These thresholds are used as guidance in SEPA review and do not necessarily preclude harvest.
8. Nesting season in Washington is defined as March 1 to August 31.

## LISTING FACTOR E: OTHER NATURAL OR MANMADE FACTORS AFFECTING ITS CONTINUED EXISTENCE

### Barred Owl

The three main threats to the spotted owl are competition from barred owls, past habitat loss, and current habitat loss. Barred owls reportedly have reduced spotted owl site occupancy, reproduction, and survival (see Appendix B). Limited experimental evidence, correlational studies, and copious anecdotal information all strongly suggest barred owls compete with spotted owls for nesting sites, roosting sites, and food, and possibly predate spotted owls. The threat posed by barred owls to spotted owl recovery is better understood now than when the spotted owl was listed. Because the abundance of barred owls continues to increase, the effectiveness in addressing this threat depends on action as soon as possible.

**Because the abundance of barred owls continues to increase, the effectiveness in addressing this threat depends on action as soon as possible.**

There are substantial information gaps regarding ecological interactions between spotted owls and barred owls, and how those interactions may be managed to meet the Recovery Criteria. Recovery actions should provide the information needed to identify effective management approaches and guide the implementation of appropriate management strategies. Many of the following actions should be done concurrently; Figure III-1 shows how these Actions may inform one another. The Service is the primary agent to oversee implementation of any strategy for the management of barred owls.

Coordination among all agencies and non-governmental organizations that can contribute to research on ecological interactions between spotted owls and barred owls is needed to prioritize research topics, maximize funding opportunities, minimize redundancies, increase efficiency, identify potential management strategies, and communicate with decision-makers. Included as Recovery Action 21 in the 2008 Recovery Plan, the Barred Owl Work Group was appointed as a Recovery Implementation Team to implement the 2008 Recovery Plan and has provided coordination on numerous analyses, topics and issues. Currently, representatives from 10 Federal, State and non-governmental agencies and organizations comprise the Work Group helping to implement its technical and scientific functions.

This Barred Owl Work Group is chaired by the Service and guided by its charter, along with the Northern Spotted Owl Implementation Team (NSOIT). The Barred Owl Work Group has guided, and will continue to guide, implementation of numerous recovery actions addressing the barred owl threat to spotted owls.

- ***Recovery Action 23: Analyze existing data sets from the demographic study areas relative to the effects of barred owls on spotted owl site occupancy, reproduction, and survival.***

Through implementation of this recovery action, many of the long-term demographic data sets have been studied, resulting in white papers and pending publications. Additional analysis of these data has provided a greater understanding of the effects of barred owls on spotted owl detection rates, survival, site occupancy and the role of habitat in site occupancy. The Barred Owl Work Group will continue to work with the Principal Investigators of the demographic studies to mine data as appropriate.

- ***Recovery Action 24: Establish protocols to detect barred owls and document barred owl site status and reproduction.***

Protocols to detect barred owls and document important population information, including pair status and reproduction, provide vital data needed to help manage barred owls to reduce their threat to spotted owls. A subgroup of the Barred Owl Work Group was formed in 2008 to develop a barred owl-specific survey protocol. The subgroup developed a draft protocol in 2009 with the purpose of providing a high likelihood of determining barred owl presence for research studies. During the 2009 field season, the draft protocol was tested in several areas with the objectives of determining barred owl detection rates and the survey effort needed to adequately detect barred owls. These data have been analyzed allowing the subgroup to refine the protocol based on the field tests.

- ***Recovery Action 25: Ensure that protocols adequately detect spotted owls in areas with barred owls.***

The presence of barred owls has been shown to decrease the detectability of spotted owls. Consequently, the Barred Owl Work Group enlisted scientific support and analysis from many individual spotted owl researchers from the Federal, State and private sectors across the range of the spotted owl. Additional analysis of data from demographic study areas focused on addressing the questions of: 1) what are the per visit detection rates of spotted owls with and without barred owls, and 2) what are the site occupancy rates of spotted owls at historical spotted owl sites? These efforts have led to several white papers and pending publications. A draft revised spotted owl survey protocol was released for use and comment during the 2010 field season along with direction on how to transition from the 1992 protocol. Field testing of, and commenting on, several provisions of the draft protocol will occur during the next several field seasons leading to finalization of a survey protocol.

- ***Recovery Action 26: Analyze resource partitioning of sympatric barred owls and spotted owls.***

Radio-telemetry studies of sympatric spotted and barred owls help to: determine how the two species use their habitat and resources, including prey, in various areas; identify characteristics of habitats used by spotted owls in areas with substantial barred owl populations; and determine how habitat use by barred owls and spotted owls changes as barred owl numbers increase.

In anticipation of the need for this information, several research projects were initiated in 2007 and led by USGS, PNW, OSU and private industry researchers. This research is focused on interspecific competition and niche partitioning by spotted owls and barred owls. Results from the research are either incorporated in Appendix B or soon will be released in peer-reviewed publications. This information will provide the opportunity for adaptive management of this Revised Recovery Plan when it becomes available.

- ***Recovery Action 27: Create and implement an outreach strategy to educate the public about the threat of barred owls to spotted owls.***

Outreach and education are important components in addressing the barred owl threat, and we continue to look for opportunities to provide this. For example, since completion of the 2008 Recovery Plan, a Barred Owl Stakeholder Group has been formed. The Barred Owl Stakeholder Group, comprised of nearly 40 private and public stakeholders with interest in spotted owl and barred owl issues, met twice in 2009 with members of the barred owl work group and a professional ethicist to discuss the ethical considerations associated with permitting the experimental removal of barred owls and provided their individual feedback on the issue. The results of these discussions are part of the pre-scoping process, and are being considered, along with the results of public scoping, in the development of the draft EIS for issuance of a permit for barred owl removal to ensure we are aware of all potential issues. We will be conducting extensive outreach as part of the NEPA process for issuance of the Migratory Bird Treaty Act permit for the experimental removal of barred owls.

It is crucial that the general public be kept informed concerning this difficult aspect of spotted owl recovery and the potential consequences of not addressing this threat. Public outreach could include production and distribution of brochures, kiosk displays, press releases, and public meetings relative to research and management options.

- ***Recovery Action 28: Expedite permitting of experimental removal of barred owls.***

The concern regarding the current and future negative effects of barred owls on the recovery of spotted owls is considerable, and immediate research is needed. State and Federal permitting of scientifically sound research on removal experiments will be necessary to answer the question of the impacts of barred owls on spotted owls.

- ***Recovery Action 29: Design and implement large-scale control experiments to assess the effects of barred owl removal on spotted owl site occupancy, reproduction, and survival.***

We believe removal of barred owls would provide benefits to spotted owls in the vicinity of the removal and may have larger population effects. Given the rapidity and severity of the increasing threat from barred owls, barred owl removal should be initiated as soon as possible in the form of well-designed removal experiments. These experiments will have the potential to substantially expand our knowledge of the ecological interactions between spotted owls and barred owls (Dugger *et al.* in press) and the effectiveness of barred owl removal in recovering spotted owls. Removal experiments should be conducted in various parts of the spotted owl's range, including a range of barred owl/spotted owl densities, to provide the most useful scientific information.

In the fall of 2009 the Service initiated an Environmental Impact Statement for a proposed experimental removal of barred owls to determine if the removal benefits spotted owls. Public scoping was completed in January 2010 and a draft Environmental Impact Statement is in process.

- ***Recovery Action 30: Manage to reduce the negative effects of barred owls on spotted owls so that Recovery Criterion 1 can be met.***

Implement the results of research to adaptively manage the effects of barred owls to meet Recovery Criterion 1. Management could include silvicultural treatments for stand structure and composition (*e.g.*, habitat management for spotted owl prey), local or large-scale control of barred owl populations, and/or other activities at present unforeseen but informed by research results.

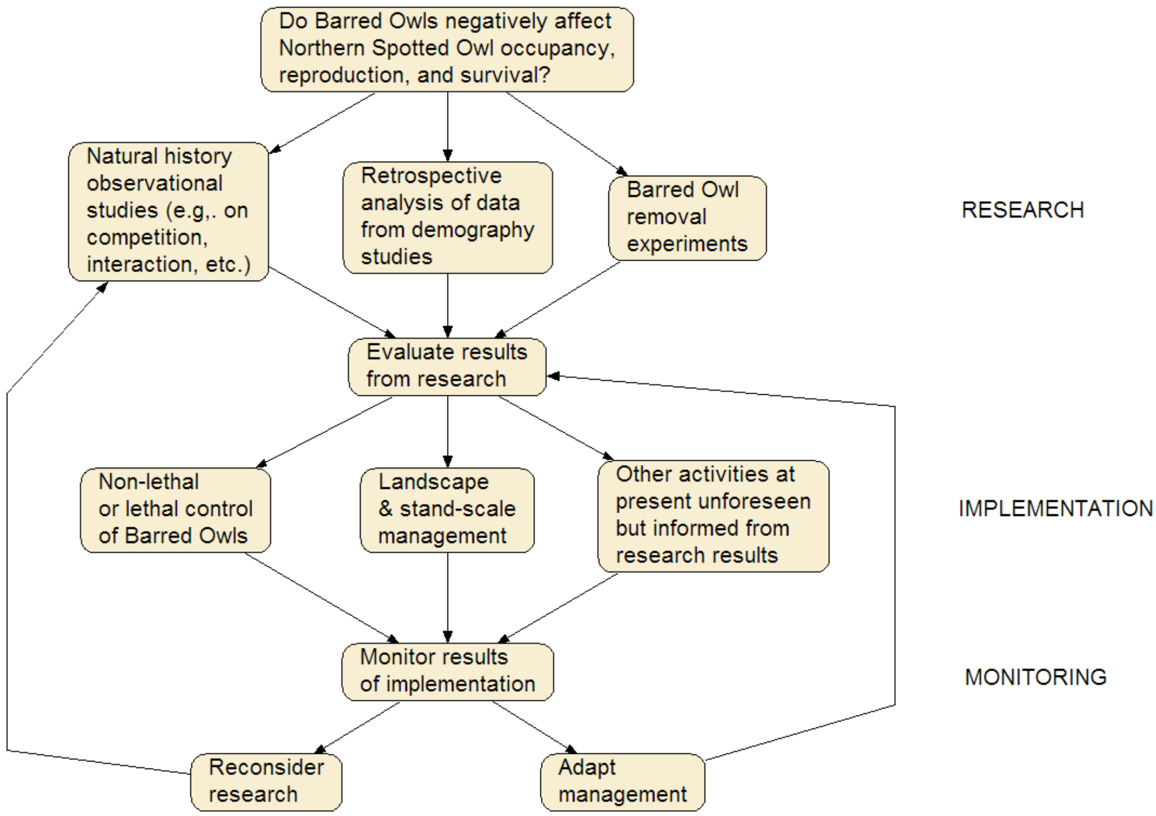



**Figure III-1.** Flowchart of barred owl Recovery Actions.

Conducting natural history studies (Figure III-1) is ongoing. Retrospective analysis of data from past and ongoing studies involves evaluating past data sets from demography study areas by adding barred owl covariates to test whether presence of barred owls affected detection rates, occupancy, reproduction, and survival of spotted owls (Dugger *et al.* 2009, Forsman *et al.* 2011, Dugger *et al.* in press). Many actions (*e.g.,* additional analysis of data, improving detection protocols for both species', outreach, identification of key spotted owl areas) have already begun. Preliminary findings from barred owl removal experiments could be realized in 1-3 years, whereas estimates of spotted owl vital rates may require more time. Evaluation of results from research is ongoing, and includes research already completed. Identification of management strategies should be based on research results, considerations for different geographic areas, costs, and changes in risk-levels to spotted owls over time. This may lead to the removal of barred owls through non-lethal or lethal methods. If research indicates local or large-scale maintenance removal of barred owl populations is needed, then public outreach, coordination among agencies, Migratory Bird Treaty Act permitting, and NEPA compliance would be required. Evaluation of results from research also may result in landscape and stand-scale management of spotted owl habitat and/or other activities unforeseen at present.

- ***Recovery Action 31: Develop mechanisms for landowners and land managers to support barred owl management using a collaborative process.***

Incentives, such as easily implemented safe harbor agreements or habitat conservation plans, can decrease a private landowner's concern regarding barred owl management that may result in an increase of spotted owls, as well as the associated issues that come with a listed species under the ESA.

- ***Recovery Action 32: Because spotted owl recovery requires well distributed, older and more structurally complex multi-layered conifer forests on Federal and non-federal lands across its range, land managers should work with the Service as described below to maintain and restore such habitat while allowing for other threats, such as fire and insects, to be addressed by restoration management actions. These high-quality spotted owl habitat stands are characterized as having large diameter trees, high amounts of canopy cover, and decadence components such as broken-topped live trees, mistletoe, cavities, large snags, and fallen trees.***

Maintaining or restoring forests with high-quality habitat will provide additional support for reducing key threats faced by spotted owls. Protecting these forests should provide spotted owls high-quality refugia habitat from the negative competitive interactions with barred owls that are likely occurring where the two species' home ranges overlap. Maintaining or restoring these forests should allow time to determine both the competitive effects of barred owls on spotted owls and the effectiveness of barred owl removal measures. Forest stands or patches meeting the described conditions are a subset of NRF habitat and actual stand conditions vary across the range. These stands or patches may be relatively small but important in a local area, may not be easily discernable using remote sensing techniques, and likely require project-level analysis and field verification to identify.

This recommendation can be justified at several scales and is supported by the best available research. At the scale of a spotted owl territory, Dugger *et al.* (in press) found an inverse relationship between the amount of old forest within the core area and spotted owl extinction rates from territories. At the population scale, Forsman *et al.* (2011) found a positive relationship between recruitment of spotted owls into the overall population and the percent cover of spotted owl NRF habitat within study areas. Both of these studies provide scientific support for the value to spotted owls of retaining structurally complex stands on the landscape.

Because the characteristics of the stands or patches targeted by this recovery action vary widely across the range of the species, the Service believes implementation and/or mapping of this recovery action is best left to interagency teams with localized expertise. To facilitate implementation of this recovery action on Federal lands, local, interagency Level 1 teams should continue to identify RA 32 stands or patches when necessary and evaluate the

effects of proposed management activities in these areas on spotted owls, with assistance from management (Level 2) and Regional Technical Specialists, as needed. This approach will continue to ensure that interagency localized expertise will be utilized in identifying and managing Recovery Action 32 stands or patches and will be the result of interagency cooperation. Non-federal landowners are welcome to utilize the tools developed during the cooperative Federal process. The Service is available to assist non-federal landowners with the implementation of this recovery action.

On-the-ground application of this action has been, and continues to be, implemented on the west side of the Cascades on Federal lands as part of the level 1 team consultation process since shortly after the 2008 Recovery Plan was finalized. Our recent experience reinforces that the BLM and FS are aware of the conservation value of this recovery action and have been proactive and collaborative in the application of Recovery Action 32.

In dry forest areas, actively manage habitat to meet the overlapping goals of spotted owl recovery, restoration of dry forest structure, composition and process including fire, insects and disease. Managers should refer to earlier discussions in this Plan for specific recommendations about landscape scale, science based adaptive restoration treatments to meet Recovery Action 32 goals. Land managers that utilize and document the application of these recommendations in their project planning are consistent with the intent of Recovery Action 32. An existing example of a site-specific plan that could be emulated at the National Forest, BLM District, or project level in other dry forest areas is the Okanogan-Wenatchee National Forest Restoration Strategy (USDA 2010).

The Dry Cascades and the Klamath Province Work Groups will both assist the Service with implementation of this recovery plan by developing multiple province-specific management strategies. Given the dynamic disturbance regimes of these provinces, the strategies developed by these two work groups may address the goals of this recovery action differently than outlined above when finalized. If these strategies require amendments to this Revised Recovery Plan the Service will provide an additional opportunity for public comment.

This recovery action may be temporary in nature, until such time as the competitive pressures of the barred owl on the spotted owl can be reduced to an extent that retention of these stands or patches is not necessary for spotted owl recovery. The 5-year review process will help inform assessments of reduction of threats posed by barred owls. If the 5-year review finds this recommendation unnecessary we will amend this Revised Recovery Plan as needed.

## Post-delisting Monitoring

Once the spotted owl is delisted the Service is required to continue to monitor its population for at least 5 years to ensure it does not require the protections of the ESA after those protections have been lifted. Currently, spotted owl populations

are monitored through the demographic study areas described in Appendix A under **Population Trends and Distribution**.

Recovery Criterion 4 – Post-delisting Monitoring**:** To monitor the continued stability of the recovered spotted owl, a post-delisting monitoring plan has been developed and is ready for implementation with the States of Washington, Oregon, and California (ESA 4(g)(1)).

- ***Recovery Action 33: Develop a post-delisting monitoring plan ready for implementation with the States of Washington, Oregon, and California (ESA 4(g)(1)).*** Such a plan is necessary to meet the requirements of the ESA.

# IV. IMPLEMENTATION SCHEDULE AND COST ESTIMATES

Recovery plans are intended to assist the Service and other stakeholders in planning and implementing actions to recover or protect threatened or endangered species. The following implementation schedule identifies priority number, duration, potential stakeholders, responsible agencies, and estimated costs for the recovery actions described in this Revised Recovery Plan. It is a guide for planning and meeting the objectives discussed in this Revised Recovery Plan.

Due to the uncertainties associated with the effects of barred owl interactions, results from ongoing and new research, and habitat changes that may occur as a result of climate change, the actions needed to stabilize and begin to recover the spotted owl may change over time. The Service and other implementers of this Revised Recovery Plan will have to employ an active adaptive management strategy to achieve results and focus on the most important actions for recovery. This Revised Recovery Plan will be amended as necessary.

The implementation schedule and cost estimate (Table IV-1) outlines recovery actions and their estimated costs for the first 5 years of this recovery program; total costs are estimated for the entire 30-year period. The costs are broad estimates and identify foreseeable expenditures that could be made to implement the specific recovery actions. Actual expenditures by identified agencies and other partners will be contingent upon appropriations and other budgetary constraints.

The actions identified in the implementation schedule are those that, in our opinion, should bring about the recovery of this species. However, these actions are subject to modification as dictated by new findings, changes in the species' status, and the completion of other recovery actions. The priority for each action is assigned as follows:

**Priority 1:** An action that must be taken to prevent extinction or prevent the species from declining irreversibly in the foreseeable future.

**Priority 2:** An action that must be taken to prevent a significant decline in the species' population/habitat quality or some other significant negative impact short of extinction.

**Priority 3:** All other actions deemed necessary to meet the recovery objectives.

The column "Action Duration" indicates whether the action is one of five types. (1) Discrete actions are shown by the number of years estimated to complete the action. (2) Continuous actions are to be implemented every year once begun. (3) Ongoing actions are currently being implemented and will continue until the

action is no longer necessary. (4) Intermittent actions are to be implemented as needed. (5) "TBD" (to be determined) actions are those for which the duration was not possible to estimate.

While the ESA assigns a strong leadership role to the Service for the recovery of listed species, it also recognizes the importance of other Federal agencies, States, and other stakeholders in the recovery process. The "responsible parties" identified in the implementation schedule are those partners who can make significant contributions to specific recovery tasks and who may voluntarily participate in any aspect of recovery actions listed. In some cases, the most logical lead agency has been identified with an asterisk. The identification of agencies and other stakeholders in the implementation schedule does not constitute any additional legal responsibilities beyond existing authorities. However, parties willing to participate may benefit by being able to show in their own budgets that their funding request is for a recovery action identified in an approved recovery plan and is therefore considered a necessary action for the overall coordinated effort to recover the spotted owl. Also, section 7(a)(1) of the ESA directs all Federal agencies to use their authorities in furtherance of the purposes of the ESA by carrying out programs, such as these recovery actions, for the conservation of threatened and endangered species.

We listed the agencies and other parties that we believe are the primary stakeholders in the recovery process, and have the authority, expertise, responsibility, or expressed interest to implement a specific recovery action. However, the list of possible stakeholders is not limited to the parties below; other stakeholders are invited to participate.

There are four assumptions associated with these cost estimates:

1. Estimates include Federal government reimbursement of travel and per-diem costs of non-governmental employees to participate in recovery actions.
2. Responsible parties include both organizations that carry out the activity and organizations that fund the activity.
3. The cost of each Action is estimated independently, unless otherwise noted.
4. The opportunity cost of managing these lands for spotted owls instead of other uses is not included in this analysis.

For most of the actions identified in this Revised Recovery Plan, there is no way of deriving a precise cost estimate. A variety of assumptions were used to produce these estimates. For actions that called for meetings or formation of work groups, we assumed the cost of meetings based on the cost of a single Recovery Team meeting. For research and monitoring related actions, current similar research or monitoring projects were used as surrogates to estimate these costs. In some cases, researchers were asked to estimate the cost of a particular study or monitoring program. The cost estimates shown include certain actions that have no new costs (*e.g.*, certain agencies or organizations are already staffed and committed to participating in some of the actions identified).

Several actions call for habitat alteration to benefit the spotted owl. These comprise two categories: actions calling for modification of existing practices to benefit the spotted owl, and actions calling for specific types of management. For modifications of existing practices, the cost of adjusting the action during planning was estimated, rather than the actual entire cost of implementing the project since the "existing practices" cost would already be incurred by the land manager. For the actions that call for specific management, actual estimates for conducting a given type of management were used, but the cost attributable to spotted owl recovery was set at 10 percent of this total cost as an estimate of the added cost to the agencies of implementing such actions. To complete the estimates for some habitat-related actions, base numbers were obtained using the costs and accomplishments of the FS and BLM within the range of the spotted owl.

The costs are broad estimates and identify foreseeable expenditures that could be made to implement the specific recovery actions. Actual expenditures by identified agencies and other partners will be contingent upon appropriations and other budgetary constraints. There are no recovery actions for Listing Factor B.

In Table IV-1, "Land managers" means non-federal land managers, "Landowners" means non-federal landowners, and "States" means State governments of Washington, Oregon, and California. For some recovery actions the interagency Northern Spotted Owl Implementation Team is identified as a responsible party. In these cases it is likely the Northern Spotted Owl Implementation Team will coordinate within their agencies to complete these actions as opposed to the Northern Spotted Owl Implementation Team itself actually carrying out the activity.

**Table IV-1.** Implementation schedule and cost estimates.

| Action No. | Priority No. | Action Description | Action Duration | Resp. Parties (* = lead) | FY Cost Estimate (in $1,000s) 30-yr Total | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Establish FWS spotted owl implementation structure | Continuous | FWS | 180 | 6 | 6 | 6 | 6 | 6 |
| 2 | 3 | Monitor population trend | Ongoing | FWS, FS, BLM*, NPS, NSOIT | 69,000 | 2,300 | 2,300 | 2,300 | 2,300 | 2,300 |
| 3 | 3 | Monitor occupancy through surveys or modeling | Start TBD, intermittent thereafter | NSOIT | 7,500 | 0 | 0 | 0 | 0 | 0 |
| **Listing Factor A: The present or threatened destruction, modification, or curtailment of the species' habitat or range** | | | | | | | | | | |
| 4 | 1 | Utilize habitat modeling framework for Recovery measures | Continuous | FWS*, BLM, FS, States, NPS | 140 | 80 | 60 | 0 | 0 | 0 |
| 5 | 2 | FWS to consider and incorporate climate change impacts on spotted owls into planning | Continuous | FWS* | 350 | 20 | 20 | 20 | 20 | 20 |
| 6 | 1 | West side: Manage to accelerate structural complexity | Continuous | FS, BLM, FWS | 1,750 | 150 | 150 | 100 | 50 | 50 |
| 7 | 1 | Create Dry Cascades Work Group (DCWG) | Up to 10 years | FWS*, FS, BLM | 230 | 35 | 35 | 20 | 20 | 20 |
| 8 | 3 | Fire and occupancy data analysis | 3 years | DCWG | 60 | 25 | 25 | 10 | 0 | 0 |
| 9 | 1 | Create Klamath Province Work Group (KPWG) | Up to 10 years | FWS*, FS,BLM | 200 | 20 | 20 | 20 | 20 | 20 |
| 10 | 1 | Conserve spotted owl sites and high value habitat for demographic support | Continuous | FS, BLM, FWS | 1,600 | 100 | 100 | 50 | 50 | 50 |

**Table IV-1.** Implementation schedule and cost estimates.

| Action No. | Priority No. | Action Description | Action Duration | Resp. Parties (* = lead) | FY Cost Estimate (in $1,000s) 30-yr Total | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 3 | Design and conduct experiments concerning habitat, prey and spotted owl fitness and thinning | Intermittent to Continuous | FS, BLM, FWS, NPS, WDNR, ODF, CAL FIRE, CDFG, landowners | 1,500 | 50 | 50 | 50 | 50 | 50 |
| 12 | 2 | Post-fire management in lands managed for spotted owl habitat development | Continuous | FWS, FS, BLM | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 3 | Standardize habitat definitions | 2 years | NSOIT, FS, BLM | 200 | 100 | 100 | 0 | 0 | 0 |
| 14 | 3 | Encourage development of HCPs and SHAs that are consistent with spotted owl recovery | Continuous | FWS | 1,500 | 50 | 50 | 50 | 50 | 50 |
| 15 | 3 | Solicit recommendations for non-federal landowner incentives | Continuous | FWS | 1,500 | 50 | 50 | 50 | 50 | 50 |
| 16 | 2 | Long-term maintenance of forest management infrastructure | Continuous | FS, BLM, FWS, States, Counties | 0 | 0 | 0 | 0 | 0 | 0 |
| **Listing Factor C: Disease or predation** | | | | | | | | | | |
| 17 | 3 | Monitor and address diseases | Continuous | NSOIT | 300 | 10 | 10 | 10 | 10 | 10 |
| **Listing Factor D: Inadequacy of existing regulatory mechanisms** | | | | | | | | | | |
| 18 | 2 | WA State Forest Practices Board evaluation of strategic non-federal spotted owl contributions | 3 years | WA State Forest Practices Board*, WA Dept. of Natural Resources, WA Dept. | 450 | 150 | 150 | 150 | 0 | 0 |

**Table IV-1.** Implementation schedule and cost estimates.

| Action No. | Priority No. | Action Description | Action Duration | Resp. Parties (* = lead) | FY Cost Estimate (in $1,000s) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 30-yr Total | 2011 | 2012 | 2013 | 2014 | 2015 |
| | | | | of Fish and Wildlife | | | | | | |
| 19 | 2 | Cooperate with ODF on scientific evaluation of potential role of State and private lands, and the effectiveness of Oregon Forest Practices rules | 5 years | ODF*, FWS | 450 | 100 | 100 | 100 | 100 | 50 |
| 20 | 2 | Work with CAL FIRE on recovery role on non-federal lands and evaluation/implementation of conservation tools | Continuous | CAL FIRE*, FWS | 730 | 10 | 80 | 80 | 80 | 20 |
| 21 | 2 | FWS work with CAL FIRE to provide Forest Practice Rules for spotted owls | 3 years | CAL FIRE, FWS | 310 | 0 | 100 | 100 | 100 | 0 |
| 22 | 2 | If necessary, work with State of California on options to allow lethal control of barred owls | 4 years | State of Cal*, FWS | 200 | 50 | 50 | 50 | 50 | 0 |
| **Listing Factor E: Other natural or manmade factors affecting its continued existence** | | | | | | | | | | |
| 23 | 2 | Analyze existing data sets for effects of barred owls | 5 years | BOWG*, FWS, FS, BLM, NPS | 250 | 50 | 50 | 50 | 50 | 50 |
| 24 | 2 | Establish protocols to detect barred owls | 2 years | BOWG*, FWS, FS, BLM, NPS | 150 | 75 | 75 | 0 | 0 | 0 |
| 25 | 2 | Ensure protocols adequately detect spotted owls | 3 years | BOWG*, FWS, BLM, FS, NPS, States, landowners | 300 | 100 | 100 | 100 | 0 | 0 |

**Table IV-1.** Implementation schedule and cost estimates.

| Action No. | Priority No. | Action Description | Action Duration | Resp. Parties (* = lead) | FY Cost Estimate (in $1,000s) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 30-yr Total | 2011 | 2012 | 2013 | 2014 | 2015 |
| 26 | 2 | Analyze resource partitioning | 5 years | BOWG*, USGS, FS, FWS, NPS, BLM | 1,820 | 190 | 510 | 440 | 440 | 120 |
| 27 | 2 | Implement public outreach strategy | Continuous | BOWG*, FWS | 48 | 15 | 5 | 1 | 1 | 1 |
| 28 | 1 | Expedite permitting of experimental removals | 3 years | FWS*, States | 45 | 0 | 0 | 0 | 15 | 15 |
| 29 | 1 | Conduct experimental removal studies | 10 years | BOWG*, TBD | 3,000 | 0 | 0 | 600 | 600 | 600 |
| 30 | 1 | Manage negative effects of barred owls | Start time 4 years away, continuous once started | BOWG*, FS, BLM, NPS, States, FWS, landowners | 31,860 | 0 | 0 | 0 | 1,180 | 1,180 |
| 31 | 2 | Develop mechanisms to support barred owl management | 2 years to develop; intermittent as needed | BOWG*, FWS, FS, BLM, NPS, States, landowners | 360 | 40 | 40 | 20 | 0 | 20 |
| 32 | 1 | Maintain high-quality habitat across all landscapes | Continuous | FWS, BLM, FS, States | 1040 | 100 | 100 | 30 | 30 | 30 |
| 33 | 3 | Develop delisting monitoring plan | 1 year; initiation TBD | FWS | 30 | 0 | 0 | 0 | 0 | 0 |
| Estimated total cost for all actions for 30 years: $127.1. million | | | | | | | | | | |

# Appendix A. Background

This section of the Revised Recovery Plan is designed to provide information necessary to understand the Revised Recovery Plan's strategy, goals, objectives, and criteria for the spotted owl. While it is not an exhaustive review, information on the spotted owl's status, basic ecology, demography, and past and current threats is included. Detailed accounts of the taxonomy, ecology, and reproductive characteristics of the spotted owl were presented in the 1987 and 1990 Status Reviews (USFWS 1987, 1990a), 1989 Status Review Supplement (USFWS 1989), Interagency Scientific Committee Report (Thomas *et al.* 1990), Forest Ecosystem Management Assessment Team (FEMAT) Report (USDA *et al.* 1993), final rule designating the spotted owl as a threatened species (USFWS 1990b), scientific evaluation of the status of the spotted owl (Courtney *et al.* 2004), and several key monographs (*e.g.*, Forsman *et al.* 2004, Anthony *et al.* 2006).

## Species Description and Taxonomy

The spotted owl is a medium-sized owl and is the largest of the three subspecies of spotted owls (Gutiérrez *et al.* 1995). It is approximately 46 to 48 centimeters (18 inches to 19 inches) long and the sexes are dimorphic, with males averaging about 13 percent smaller than females. The mean mass of 971 males taken during 1,108 captures was 580.4 grams (1.28 pounds) (range = 430.0 to 690.0 grams) (0.95 pound to 1.52 pounds), and the mean mass of 874 females taken during 1,016 captures was 664.5 grams (1.46 pounds) (range = 490.0 to 885.0 grams) (1.1 pounds to 1.95 pounds) (P. Loschl and E. Forsman pers. comm. 2006). The spotted owl is dark brown with a barred tail and white spots on its head and breast, and it has dark brown eyes surrounded by prominent facial disks. Four age classes can be distinguished on the basis of plumage characteristics (Forsman 1981, Moen *et al.* 1991). The spotted owl superficially resembles the barred owl, a species with which it occasionally hybridizes (Kelly and Forsman 2004). Hybrids exhibit physical and vocal characteristics of both species (Hamer *et al.* 1994).

The northern spotted owl is one of three subspecies of spotted owls recognized by the American Ornithologists' Union. The taxonomic separation of these three subspecies is supported by genetic (Barrowclough and Gutiérrez 1990, Barrowclough *et al.* 1999, Haig *et al.* 2004), morphological (Gutiérrez *et al.* 1995), and biogeographic information (Barrowclough and Gutiérrez 1990). The distribution of the Mexican subspecies (*S. o. lucida*) is separate from those of the northern and California (*S. o. occidentalis*) subspecies (Gutiérrez *et al.* 1995). Recent studies analyzing mitochondrial DNA sequences (Haig *et al.* 2004, Chi *et al.* 2005, Barrowclough *et al.* 2005) and microsatellites (Henke *et al.* 2005) confirmed the validity of the current subspecies designations for northern and California spotted owls. The narrow hybrid zone between these two subspecies, which is located in the southern Cascades and northern Sierra Nevadas, appears to be stable (Barrowclough *et al.* 2005).

# Population Trends and Distribution

There are no estimates of the size of the spotted owl population prior to settlement by Europeans. Spotted owls are believed to have inhabited most old-growth forests or stands throughout the Pacific Northwest, including northwestern California, prior to beginning of modern settlement in the mid-1800s (USFWS 1989).

The current range of the spotted owl extends from southwest British Columbia through the Cascade Mountains, coastal ranges, and intervening forested lands in Washington, Oregon, and California, as far south as Marin County (USFWS 1990b). The range of the spotted owl is partitioned into 12 physiographic provinces (Figure A-1) based on recognized landscape subdivisions exhibiting different physical and environmental features (Thomas *et al.* 1993). These provinces are distributed across the species' range as follows:

- Four provinces in Washington: Eastern Washington Cascades, Olympic Peninsula, Western Washington Cascades, Western Washington Lowlands
- Five provinces in Oregon: Oregon Coast Range, Willamette Valley, Western Oregon Cascades, Eastern Oregon Cascades, Oregon Klamath
- Three provinces in California: California Coast, California Klamath, California Cascades

The spotted owl has become rare in certain areas, such as British Columbia, southwestern Washington, and the northern coastal ranges of Oregon.

As of July 1, 1994, there were 5,431 known site-centers of spotted owl pairs or resident singles: 851 sites (16 percent) in Washington, 2,893 sites (53 percent) in Oregon, and 1,687 sites (31 percent) in California (USFWS 1995). By June 2004, the number of territorial spotted owl sites recognized by Washington Department of Fish and Wildlife was 1,070 (J. Buchanan pers. comm. 2010). The actual number of currently occupied spotted owl locations across the range is unknown because not all areas have been or can be surveyed on an annual basis (USFWS 1992a, Thomas *et al.* 1993). In addition, many historical sites are no longer occupied because spotted owls have been displaced by barred owls, timber harvest, or severe fires, and it is possible that some new sites have been established due to recruitment of new areas into NRF habitat since 1994. The totals in USFWS (1995) represent the cumulative number of locations recorded in the three States, not population estimates.

**Many historical spotted owl sites are no longer occupied because spotted owls have been displaced by barred owls, timber harvest, or fires.**

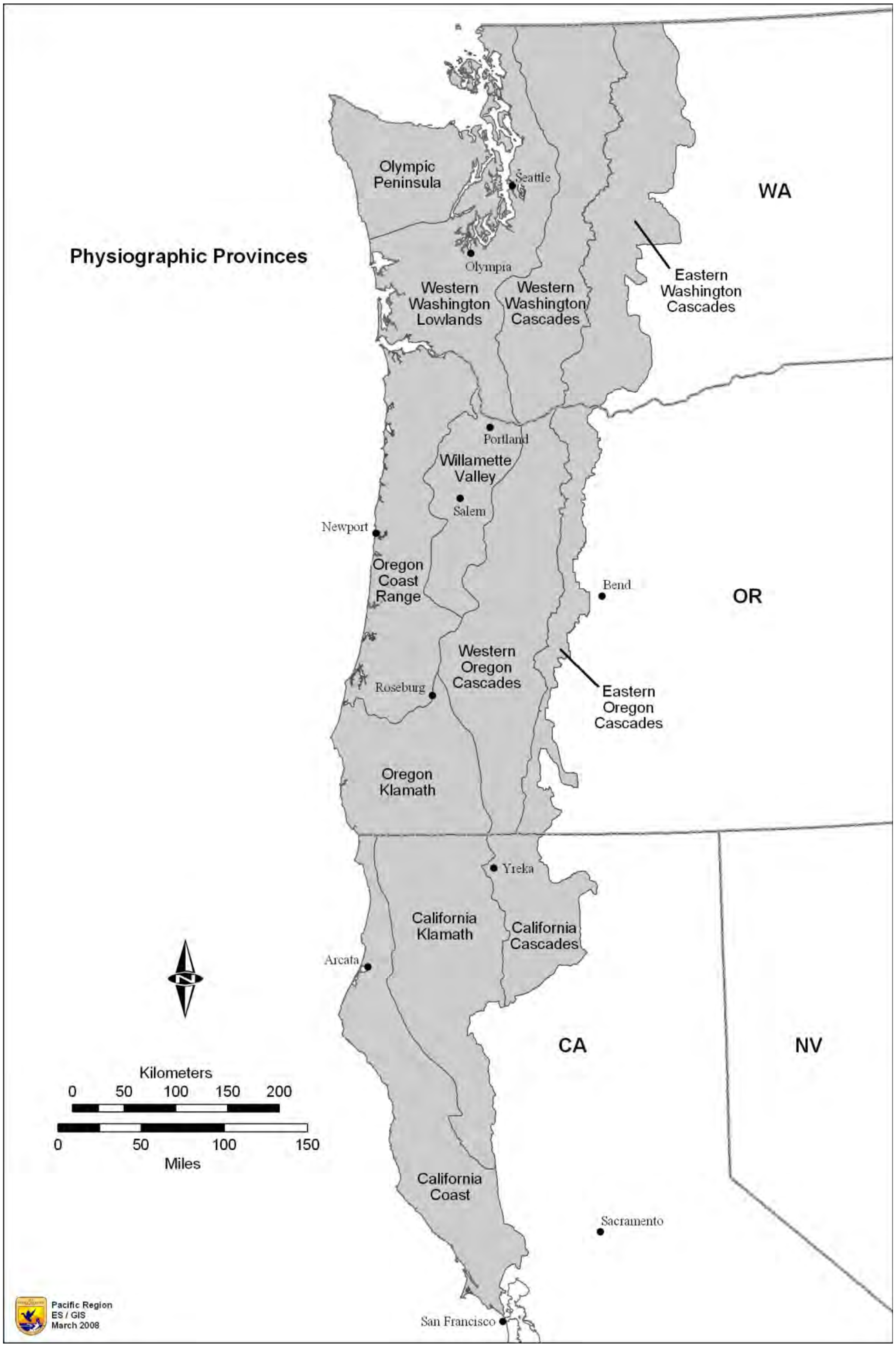



**Figure A-1.** Physiographic provinces within the range of the spotted owl in the United States.

Because the existing survey coverage and effort are insufficient to produce reliable range-wide estimates of population size, demographic data are used to evaluate trends in spotted owl populations. Analysis of demographic data can provide an estimate of the finite rate of population change ($\lambda$) (lambda), which provides information on the direction and magnitude of population change. A $\lambda$ of 1.0 indicates a stationary population, meaning the population is neither increasing nor decreasing. A $\lambda$ of less than 1.0 indicates a decreasing population, and a $\lambda$ of greater than 1.0 indicates a growing population. Demographic data, derived from studies initiated as early as 1985, have been analyzed periodically (Anderson and Burnham 1992, Burnham *et al.* 1994, Forsman *et al.* 1996, Anthony *et al.* 2006, Forsman *et al.* 2011) to estimate trends in the populations of the spotted owl.

In January 2009, two meta-analyses modeled rates of population change for up to 24 years using the re-parameterized Jolly-Seber method ($\lambda_{RJS}$). One meta-analysis modeled the 11 long-term study areas (Table A-1), while the other modeled the eight study areas that are part of the effectiveness monitoring program of the NWFP (Forsman *et al.* 2011).

Point estimates of $\lambda_{RJS}$ were all below 1.0 and ranged from 0.929 to 0.996 for the 11 long-term study areas. There was strong evidence that populations declined on 7 of the 11 areas (Forsman *et al.* 2011), these areas included Rainier, Olympic, Cle Elum, Coast Range, HJ Andrews, Northwest California and Green Diamond. On the other four areas (Tyee, Klamath, Southern Cascades, and Hoopa), populations were either stable, or the precision of the estimates was not sufficient to detect declines.

The weighted mean $\lambda_{RJS}$ for all of the 11 study areas was 0.971 (standard error [SE] = 0.007, 95 percent confidence interval [CI] = 0.960 to 0.983), which indicated an average population decline of 2.9 percent per year from 1985 to 2006. This is a lower rate of decline than the 3.7 percent reported by Anthony *et al.* (2006), but the rates are not directly comparable because Anthony *et al.* (2006) examined a different series of years and because two of the study areas in their analysis were discontinued and not included in Forsman *et al.* (2011). Forsman *et al.* (2011) explains that the indication populations were declining was based on the fact that the 95 percent confidence intervals around the estimate of mean lambda did not overlap 1.0 (stable) or barely included 1.0. While estimates of mean $\lambda_{RJS}$ are not directly comparable between Anthony *et al.* (2006) and Forsman *et al.* (2011), results from these studies indicate that rates of population decline for spotted owls have not moderated in recent years. In the most recent meta-analysis, Forsman *et al.* (2011) indicated that the number of populations that showed declines and the rates of decline on study areas in Washington and northern Oregon were noteworthy and should be cause for concern for the long-term sustainability of spotted owl populations throughout the range of the subspecies.

**Demographic data suggest that populations over the 11 long-term demographic study areas decreased by about 2.9 percent from 1985 to 2006.**

**Table A-1.** Spotted owl demographic parameters based on data from the spotted owl demographic study areas (adapted from Forsman *et al.* 2011).

| Study Area | Fecundity | Apparent Survival[1] | $\lambda_{RJS}$ | Population change[2] |
|---|---|---|---|---|
| Cle Elum | Declining | Declining | 0.937 | Declining |
| Rainier | Increasing | Declining | 0.929 | Declining |
| Olympic | Stable | Declining | 0.957 | Declining |
| Coast Ranges | Increasing | Declining since 1998 | 0.966 | Declining |
| HJ Andrews | Increasing | Declining since 1997 | 0.977 | Declining |
| Tyee | Stable | Declining since 2000 | 0.996 | Stationary |
| Klamath | Declining | Stable | 0.990 | Stationary |
| Southern Cascades | Declining | Declining since 2000 | 0.982 | Stationary |
| NW California | Declining | Declining | 0.983 | Declining |
| Hoopa | Stable | Declining since 2004 | 0.989 | Stationary |
| Green Diamond | Declining | Declining | 0.972 | Declining |

[1]Apparent survival calculations are based on model average.
[2]Population trends are based on estimates of realized population change.

The mean $\lambda_{RJS}$ for the eight demographic monitoring areas (Cle Elum, Olympic, Coast Range, HJ Andrews, Tyee, Klamath, Southern Cascades, and Northwest California) that are part of the effectiveness monitoring program of the NWFP was 0.972 (SE = 0.006, 95 percent CI = 0.958 to 0.985), which indicated an estimated decline of 2.8 percent per year on Federal lands within the range of the spotted owl. The weighted mean estimate $\lambda_{RJS}$ for the other three study areas (Rainier, Hoopa, and Green Diamond) was 0.969 (SE = 0.016, 95 percent CI = 0.938 to 1.000), yielding an estimated average decline of 3.1 percent per year. These data suggest that demographic rates for spotted owl populations on Federal lands were somewhat better than elsewhere; however, this comparison is confounded by the interspersion of non-federal land in study areas and the likelihood that spotted owls use habitat on multiple ownerships in some demography study areas.

The number of populations that declined and the rate at which they have declined are noteworthy, particularly the precipitous declines in the Olympic, Cle Elum, and Rainier study areas in Washington and the Coast Range study area in Oregon. Estimates of population declines in these areas ranged from 40 to 60 percent during the study period through 2006 (Forsman *et al.* 2011). Spotted owl populations on the HJ Andrews, Northwest California, and Green Diamond study areas declined by 20-30 percent whereas the Tyee, Klamath, Southern Cascades, and Hoopa study areas showed declines of 5 to 15 percent.

**Decreases in adult apparent survival rates were an important factor contributing to decreasing population trends.**

Decreases in adult apparent survival rates were an important factor contributing to decreasing population trends. Forsman *et al.* (2011) found apparent survival rates were declining on 10 of the study areas with the Klamath study area in Oregon being the exception. Estimated declines in adult survival were most precipitous in Washington where apparent survival rates were less than 80 percent in recent years, a rate that may not allow for sustainable populations (Forsman *et al.* 2011). In addition, declines in adult survival for study areas in Oregon have occurred predominately within the last five years and were not observed in the previous analysis by Anthony *et al.* 2006. Forsman *et al.* (2011) express concerns about the collective declines in adult survival across the subspecies range because spotted owl populations are most sensitive to changes in adult survival.

There are few spotted owls remaining in British Columbia. Chutter *et al.* (2004) suggested immediate action was required to improve the likelihood of recovering the spotted owl population in British Columbia. In 2007, the Spotted Owl Population Enhancement Team recommended to remove spotted owls from the wild in British Columbia. The primary recommendation consisted of two different options – 1) remove all spotted owls immediately and 2) remove most spotted owls in the first year and evaluate subsequently the need to remove additional spotted owls. The second option was selected for implementation (Fenger *et al.* 2007). Personnel in British Columbia captured and brought into captivity the remaining 16 known wild spotted owls. Prior to initiating the captive-breeding program, the population of spotted owls in Canada was declining by as much as 35 percent per year (Chutter *et al.* 2004). The amount of previous interaction between spotted owls in Canada and the United States is unknown (Chutter *et al.* 2004).

# Life History and Ecology

Spotted owls are territorial and usually monogamous. Home-range sizes vary geographically, generally increasing from south to north (USFWS 1990b). Estimates of median size of their annual home range vary from 2,955 acres in the Oregon Cascades (Thomas *et al.* 1990) to 14,211 acres on the Olympic Peninsula (Forsman *et al.* 2001). Zabel *et al.* (1995) showed that spotted owl home ranges are larger where flying squirrels are the predominant prey and smaller where wood rats are the predominant prey. Home ranges of adjacent pairs overlap (Forsman *et al.* 1984, Solis and Gutiérrez 1990), suggesting that the defended area is smaller than the area used for foraging. The portion of the home range used during the breeding season is smaller than that used in the remainder of the year (Forsman *et al.* 1984, Sisco 1990).

**The spotted owl is relatively long-lived, has a long reproductive life span, invests significantly in parental care, and exhibits high adult survivorship relative to other North American owls.**

The spotted owl is relatively long-lived, has a long reproductive life span, invests significantly in parental care, and exhibits high adult survivorship relative to other North American owls (Forsman *et al.* 1984, Gutiérrez *et al.* 1995). Spotted owls are sexually mature at 1 year of age, but rarely breed until they are 2 to 5 years of age (Miller *et al.* 1985, Franklin 1992, Forsman *et al.* 2002). Breeding females lay one to four eggs per clutch, with the average clutch size being two eggs; however, most spotted owl pairs do not nest every year, nor are nesting pairs successful every year (Forsman *et al.* 1984, USFWS 1990b, Anthony *et al.* 2006). The small clutch size, temporal variability in nesting success, and delayed onset of breeding all contribute to the relatively low fecundity of this species (Gutiérrez 1996).

Courtship behavior usually begins in February or March, and females typically lay eggs in late March or April. The timing of nesting and fledging varies with latitude and elevation (Forsman *et al.* 1984). After they leave the nest in late May or June, juvenile spotted owls depend on their parents until they are able to fly and hunt on their own. Parental care continues after fledging into September (Forsman *et al.* 1984, USFWS 1990b). During the first few weeks after the young leave the nest, the adults often roost with them during the day. By late summer, the adults are rarely found roosting with their young and usually only visit the juveniles to feed them at night (Forsman *et al.* 1984).

Natal dispersal of spotted owls typically begins in September and October with a few individuals dispersing in November and December (Miller *et al.* 1997, Forsman *et al.* 2002). Natal dispersal occurs in stages. Juveniles will settle for up to seven months at temporary locations between larger movements (Miller *et al.* 1997, Forsman *et al.* 2002) and may do this multiple times before establishing a territory. The median natal dispersal distance from fledging

**Dispersing juvenile spotted owls experience high mortality rates, exceeding 70 percent in some studies. Known or suspected causes of mortality during dispersal include starvation, predation, and accidents.**

to "permanent" settlement is about 10 miles for males and 15.5 miles for females (Forsman *et al.* 2002).

During the transience (movement) phase, dispersers used mature and old-growth forest slightly more than its availability. Habitat supporting the transience phase of dispersal contains stands with adequate tree size and canopy closure to provide protection from avian predators and minimal foraging opportunities. This may include younger and less diverse forest stands than foraging habitat, such as even-aged, pole-sized stands, but such stands should contain some roosting structures and foraging habitat to allow for temporary resting and feeding during the movement phase. While the stand-level and landscape-level attributes of forests needed to facilitate successful dispersal have not been thoroughly evaluated (Buchanan 2004), an early attempt to describe dispersal conditions in the Interagency Scientific Committee (ISC) Report (Thomas *et al.* 1990) recommended managing the forested landscape such that 50 percent of each quarter-township has a mean diameter at breast height (dbh) of at least 11 inches and a canopy closure of at least 40 percent (the 50-11-40 rule). The minimum levels of this definition describe habitat supporting the transient phase of dispersal.

Spotted owl dispersal needs are better assessed at the landscape scale than at the stand- or habitat-patch scale (Thomas *et al.* 1990). Existing land allocations and congressional designations (*e.g.*, Wilderness Areas, Wild and Scenic Rivers, etc.) contribute significantly to spotted owl dispersal in some areas, but are not evenly distributed across the landscape. For example, many wilderness areas contain little spotted owl habitat due to elevation or topography. Spotted owls are able to move successfully through highly fragmented landscapes typical of the mountain ranges in western Washington and Oregon (Forsman *et al.* 2002). Still, barriers to spotted owl dispersal do exist and likely include large tracts of unforested lands, such as the Willamette, Rogue and Umpqua valleys and broad expanses of open water, such as Hood Canal and Puget Sound (Forsman *et al.* 2002). Spotted owls have dispersed from the Coastal Mountains to the Cascades Mountains in Oregon though broad forested regions between the Willamette, Umpqua, and Rogue Valleys of Oregon (Forsman *et al.* 2002, p. 22). These "corridors" primarily support relatively rapid movement through such areas, rather than colonization.

During the colonization phase, mature and old growth forest was used at nearly twice its availability (Miller *et al.* 1997). Closed pole-sapling-sawtimber habitat was used roughly in proportion to availability in both phases and may represent the minimum condition for movement. Open sapling and clearcuts were used less than expected based on availability during colonization (Miller *et al.* 1997). Habitat supporting the colonization phase of dispersal is generally equivalent to roosting and foraging habitat, although it may be in smaller amounts than needed to support nesting pairs.

Successful juvenile dispersal may depend on locating unoccupied NRF habitat in close proximity to other occupied sites (LaHaye *et al.* 2001). Spotted owls regularly disperse through highly fragmented forested landscapes that are

typical of the mountain ranges in western Washington and Oregon (Forsman *et al.* 2002), and have dispersed from the Coastal Mountains to the Cascades Mountains in the broad forested regions between the Willamette, Umpqua, and Rogue Valleys of Oregon (Forsman *et al.* 2002). Corridors of forest through fragmented landscapes serve primarily to support relatively rapid movement through such areas, rather than colonization.

Dispersing juvenile spotted owls experience high mortality rates (more than 70 percent in some studies (Miller 1989, Franklin *et al.* 1999, USFWS 1990b) from starvation, predation, and accidents (Miller 1989, Forsman *et al.* 2002). Parasitic infection may contribute to these causes of mortality, but the relationship between parasite loads and survival is poorly understood (Gutiérrez 1989, Hoberg *et al.* 1989, Forsman *et al.* 2002). Juvenile dispersal is thus a highly vulnerable life stage for spotted owls, and enhancing the survivorship of juveniles during this period could play an important role in maintaining stable populations of spotted owls.

Analysis of the genetic structure of spotted owl populations suggests that gene flow may have been adequate between the Olympic Mountains and the Washington Cascades, and between the Olympic Mountains and the Oregon Coast Range (Haig *et al.* 2001). Although telemetry and genetic studies indicate that close inbreeding between siblings or parents and their offspring is rare (Haig *et al.* 2001, Forsman *et al.* 2002), inbreeding between more distant relatives is fairly common (E. Forsman pers. comm. 2006).

Spotted owls are mostly nocturnal, although they also forage opportunistically during the day (Forsman *et al.* 1984, Sovern *et al.* 1994). The composition of the spotted owl's diet varies geographically and by forest type. Generally, flying squirrels are the most prominent prey for spotted owls in Douglas-fir and western hemlock forests (Forsman *et al.* 1984) in Washington and Oregon, while dusky-footed wood rats are a major part of the diet in the Oregon Klamath, California Klamath, and California Coastal Provinces (Forsman *et al.* 1984, 2001, 2004, Ward *et al.* 1998, Hamer *et al.* 2001). Depending on location, other important prey include deer mice, tree voles, red-backed voles, gophers, snowshoe hare, bushy-tailed wood rats, birds, and insects, although these species comprise a small portion of the spotted owl diet (Forsman *et al.* 1984, 2004, Ward *et al.* 1998, Hamer *et al.* 2001).

Effects to spotted owls from barred owls are described above in Listing Factor E.

## Habitat Characteristics

Forsman *et al.* (1984) reported that spotted owls have been observed in the following forest types: Douglas-fir, western hemlock, grand fir, white fir, ponderosa pine, Shasta red fir, mixed evergreen, mixed conifer hardwood (Klamath montane, Marin County), and redwood. In addition, spotted owls in Marin County, California use Bishop pine forests and mixed evergreen-deciduous hardwood forests. The upper elevation limit at which spotted owls occur corresponds to the transition to subalpine forest, which is characterized by

relatively simple structure and severe winter weather (Forsman 1975, Forsman *et al.* 1984).

Spotted owls generally rely on older forested habitats (Carroll and Johnson 2008) because such forests contain the structures and characteristics required for nesting, roosting, and foraging. Features that support nesting and roosting typically include a moderate to high canopy closure (60 to 90 percent); a multi-layered, multi-species canopy with large overstory trees (with dbh of greater than 30 inches); a high incidence of large trees with various deformities (large cavities, broken tops, mistletoe infections, and other evidence of decadence); large snags; large accumulations of fallen trees and other woody debris on the ground; and sufficient open space below the canopy for spotted owls to fly (Thomas *et al.* 1990). Forested stands with high canopy closure also provide thermal cover (Weathers *et al.* 2001) and protection from predators.

Foraging habitat generally has attributes similar to those of nesting and roosting habitat, but such habitat may not always support successfully nesting pairs (USFWS 1992b). Dispersal habitat, at a minimum, consists of stands with adequate tree size and canopy closure to provide protection from avian predators and at least minimal foraging opportunities (USFWS 1992b). Forsman *et al.* (2002) found that spotted owls could disperse through highly fragmented forest landscapes, yet the stand-level and landscape-level attributes of forests needed to facilitate successful dispersal have not been thoroughly evaluated (Buchanan 2004). Therefore, a more complete description of dispersal habitat may be determined in the future. There is little evidence that small openings in forest habitat influence the dispersal of spotted owls, but large, non-forested valleys such as the Willamette Valley apparently are barriers to both natal and breeding dispersal (Forsman *et al.* 2002). The degree to which water bodies, such as the Columbia River and Puget Sound, function as barriers to dispersal is unclear, although radio telemetry data indicate that spotted owls move around large water bodies rather than cross them (Forsman *et al.* 2002).

Recent landscape-level analyses in portions of southwest Oregon and California Klamath Province suggest that a mosaic of late-successional habitat interspersed with other seral conditions may benefit spotted owls more than large, homogeneous expanses of older forests in areas where woodrats are a major component of spotted owl diets (Meyer *et al.* 1998, Franklin *et al.* 2000, Zabel *et al.* 2003). In Oregon Klamath and Western Oregon Cascade Provinces, Dugger *et al.* (2005) found that apparent survival and reproduction was positively associated with the proportion of older forest near the territory center (within 730 meters) (2,395 feet). Survival decreased dramatically when the amount of non-habitat (non-forest areas, sapling stands, etc.) exceeded approximately 50 percent of the home range (Dugger *et al.* 2005). The authors concluded there was no support for either a positive or negative direct effect of intermediate-aged forest—that is, all forest stages between sapling and mature,

**One study indicated that while mid-seral and late-seral forests are important to spotted owls, a mixture of these forest types with younger forest and non-forest may be best for spotted owl survival and reproduction in certain parts of the range.**

with total canopy cover greater than 40 percent—on either the survival or reproduction of spotted owls. It is unknown how these results were affected by the low habitat fitness potential in their study area, which Dugger *et al.* (2005) stated was generally much lower than those in Franklin *et al.* (2000) and Olson *et al.* (2004), and the low reproductive rate and survival in their study area, which they reported were generally lower than those studied by Anthony *et al.* (2006). Olson *et al.* (2004) found that reproductive rates fluctuated biennially and were positively related to the amount of edge between late-seral and mid-seral forests and other habitat classes in the central Oregon Coast Range. Olson *et al.* (2004) concluded that their results indicate that while mid-seral and late-seral forests are important to spotted owls, a mixture of these forest types with younger forest and non-forest may be best for spotted owl survival and reproduction in their study area.

While the effects of wildfire on spotted owls and their habitat vary, in the fire-adapted portions of the spotted owl's range, low- to moderate-severity fires may contribute to this mixture of habitats. Bond *et al.* (2002) examined the demography of the three spotted owl subspecies after wildfires, in which wildfire burned through spotted owl nest and roost sites in varying degrees of severity[1]. Post-fire demography parameters for the three subspecies were similar or better than long-term demographic parameters for each of the three subspecies in those same areas (Bond *et al.* 2002). In a preliminary study conducted by Anthony and Andrews (2004) in the Oregon Klamath Province, their sample of spotted owls appeared to be using a variety of habitats within the area of the Timbered Rock fire, including areas where burning had been moderate. In 1994, the Hatchery Complex fire burned 17,603 hectares in the Wenatchee National Forest in Washington's eastern Cascades, affecting six spotted owl activity centers (Gaines *et al.* 1997). Spotted owl habitat within a 2.9 km (1.8 mile) radius of the activity centers was reduced by 8 to 45 percent (mean = 31 percent) as a result of the direct effects of the fire and by 10 to 85 percent (mean = 55 percent) as a result of delayed mortality of fire-damaged trees and insects. Direct mortality of spotted owls was assumed to have occurred at one site, and spotted owls were present at two of the six sites 1 year after the fire, with reproduction occurring at only one. In 1994, two wildfires burned in the Yakama Indian Reservation in Washington's eastern Cascades, affecting the home ranges of two radio-tagged spotted owls (King *et al.* 1997). Although the amount of home ranges burned was not quantified, spotted owls were observed using areas that burned at low and medium intensities. No direct mortality of spotted owls was observed, even though thick smoke covered several spotted owl site-centers for a week. Spotted owls have been observed foraging in areas

[1] Fire severity is defined in several ways. See the individual studies cited for further information on the definitions of fire severity.

burned by fires of all severity categories (Clark 2007, Bond *et al.* 2009). While Clark (2007) found that spotted owls did not use large patches of high-severity burns, Bond *et al.* (2009) found spotted owls selecting burned areas, even high-severity burns, when they were within 1.5 km of a nest or roost site. Results of several of these studies are confounded because of post-fire salvaging that occurred (*e.g.*, King *et al.* 1997, Clark 2007). More research is needed to further understand the relationship between fire and spotted owl habitat use.

Spotted owls may be found in younger forest stands that have the structural characteristics of older forests or retained structural elements from the previous forest. In redwood forests and mixed conifer-hardwood forests along the coast of northwestern California, considerable numbers of spotted owls also occur in younger forest stands, particularly in areas where hardwoods provide a multi-layered structure at an early age (Thomas *et al.* 1990, Diller and Thome 1999). The results of numerous studies of spotted owl habitat relationships in the Redwood zone suggest stump-sprouting and rapid growth rates of redwoods, combined with high availability of large-bodied prey (woodrats) in patchy, intensively-managed forests, enables spotted owls to maintain high densities in a wide range of forest structural conditions.

In mixed conifer forests in the eastern Cascades in Washington, 27 percent of nest sites were in old-growth forests, 57 percent were in the understory reinitiation phase of stand development, and 17 percent were in the stem exclusion phase (Buchanan *et al.* 1995). In the western Cascades of Oregon, 50 percent of spotted owl nests were in late-seral/old-growth stands (greater than 80 years old), and none were found in stands of less than 40 years old (Irwin *et al.* 2000).

In the western Washington Cascades, spotted owls roosted in mature forests dominated by trees greater than 50 centimeters (19.7 inches) dbh with greater than 60 percent canopy closure more often than expected for roosting during the non-breeding season. Spotted owls also used young forest (trees of 20 to 50 centimeters (7.9 inches to 19.7 inches) dbh with greater than 60 percent canopy closure) less often than expected based on this habitat's availability (Herter *et al.* 2002). In the Coast Ranges, western Oregon Cascades and the Olympic Peninsula, radio-marked spotted owls selected for old-growth and mature forests for foraging and roosting and used young forests less than predicted based on availability (Forsman *et al.* 1984, Carey *et al.* 1990, 1992, Thomas *et al.* 1990). Glenn *et al.* (2004) studied spotted owls in young forests in western Oregon and found little preference among age classes of young forest.

Habitat use also is influenced by prey availability. Ward (1990) found that spotted owls foraged in areas with lower variance in prey densities (*i.e.*, where the occurrence of prey was more predictable) within older forests and near ecotones of old forest and brush seral stages. Zabel *et al.* (1995) showed that spotted owl home ranges are larger and smaller where flying squirrels and wood rats, respectively, are the predominant prey.

## Critical Habitat

On January 15, 1992, the Service designated critical habitat for the spotted owl within 190 Critical Habitat Units encompassing nearly 6.9 million acres (2.2 million acres in Washington, 3.3 million acres in Oregon, and 1.4 million acres in California (USFWS 1992a). Primary constituent elements (the physical and biological features of critical habitat essential to a species' conservation) identified in the spotted owl critical habitat final rule include those features that support nesting, roosting, foraging, and dispersal (USFWS 1992b). In 2008 the Service completed a revision of spotted owl critical habitat, designating 5.3 million acres (1.8 million acres in Washington, 2.3 million acres in Oregon, and 1.2 million acres in California). The primary constituent elements included suitable forest types and the areas within these containing nesting, roosting, foraging, or dispersal habitat.

Revised spotted owl critical habitat was designated based on large blocks of habitat identified for spotted owl conservation in the 2008 Recovery Plan (MOCAs) on the west side of the range (USFWS 2008a). The Service designated the Federal lands within these MOCAs as critical habitat, excluding congressionally-reserved areas such as Wilderness Areas and National Parks. Because the 2008 Recovery Plan did not include mapped areas in the eastern Cascades of Oregon and Washington, focusing instead on a landscape approach, we relied on the information used to map the areas in these provinces for the 2007 draft Recovery Plan(USFWS 2007).

As part of this recovery plan, the Service has completed a habitat modeling effort which provides a more in-depth evaluation of various habitat features that affect spotted owl habitat use, when compared to the process used to develop the MOCAs. This information will be used to evaluate potential habitat conservation network scenarios. The Service will use this information and other results of the modeling as it evaluates revisions to spotted owl critical habitat.

# Conservation Efforts

## Federal Lands

Since it was signed on April 13, 1994, the NWFP has guided the management of Federal forest lands within the range of the spotted owl (USDA and USDI 1994a, b). The NWFP was designed to protect large blocks of late-successional forest and provide habitat for species that depend on those forests including the spotted owl, as well as to "produce a predictable and sustainable level of timber sales and non-timber resources that will not degrade or destroy the environment" (USDA and USDI 1994a). The NWFP includes land-use allocations that would provide for population clusters of spotted owls (*i.e.,* demographic support) and maintain connectivity between population clusters. Certain land-use allocations in the NWFP contribute to supporting population clusters: LSRs, Managed Late-Successional Areas, and Congressionally Reserved

Areas. Riparian Reserves, Adaptive Management Areas and Administratively Withdrawn Areas can provide both demographic support and connectivity/dispersal between the larger blocks, but are not necessarily designed for that purpose. Matrix areas were to support timber production while also retaining biological legacy components important to old-growth obligate species that would persist into future managed timber stands.

The NWFP was directly incorporated into 4 National Forest LRMPs and amended the LRMPs that guide the management of each of the 15 National Forests and six BLM Districts across the range of the spotted owl to adopt a series of reserves and management guidelines that were intended to protect spotted owls and their habitat. The LRMPs adopted a set of reserves and standards and guidelines described in the Record of Decision for the NWFP.

The NWFP with its rangewide network of LSRs was adapted from work completed by three previous studies (Thomas *et al.* 2006): the 1990 ISC Report (Thomas *et al.* 1990), the 1991 report for the Conservation of Late-successional Forests and Aquatic Ecosystems (Johnson *et al.* 1991), and the 1993 report of the Scientific Assessment Team (Thomas *et al.* 1993). In addition, the 1992 Draft Recovery Plan for the Northern Spotted Owl (USFWS 1992b) was based on the ISC report.

**Results from the first decade of monitoring do not provide any reason to depart from the objective of habitat maintenance and restoration as described in the Northwest Forest Plan.**

The FEMAT predicted, based on expert opinion, the spotted owl population would decline in non-reserve lands over time, while the population would stabilize and eventually increase within LSRs as habitat conditions improved over the next 50 to 100 years (USDA *et al.* 1993, USDA and USDI 1994a, b). Based on the results of the first decade of monitoring, Lint (2005) could not determine whether implementation of the NWFP would reverse the spotted owl's declining population trend because not enough time had passed to provide the necessary measure of certainty. However, the results from the first decade of monitoring do not provide any reason to depart from the objective of habitat maintenance and restoration as described in the NWFP and incorporated into LRMPs (Lint 2005, Noon and Blakesley 2006). Bigley and Franklin (2004) suggested that more fuels treatments are needed in east-side forests to preclude large-scale losses of habitat to stand-replacing wildfires. Other stressors that occur in NRF habitat, such as the range expansion of the barred owl (already in action) and infection with WNV (which may or may not occur) may complicate the conservation of the spotted owl. Recent reports about the status of the spotted owl offer few management recommendations to deal with these emerging threats.

## Non-federal Lands

In the report from the ISC (Thomas *et al.* 1990), the draft Recovery Plan (USFWS 1992b), and the report from the FEMAT (USDA *et al.* 1993), it was noted that limited Federal ownership in some areas constrained the ability to form a network of old-forest reserves to meet the conservation needs of the spotted owl. In these areas in particular, non-federal lands would be important to the range-wide goal of achieving conservation and recovery of the spotted owl.

There are 17 current and ongoing conservation plans (CP) including HCPs and SHAs that have incidental take permits issued for spotted owls—eight in Washington, three in Oregon, and six in California. The CPs range in size from 76 acres to more than 1.8 million acres, although not all acres are included in the mitigation for spotted owls. In total, the CPs cover approximately 3 million acres (9.4 percent) of the 32 million acres of non-federal forest lands in the range of the spotted owl. The period of time that the HCPs will be in place ranges from 20 to 100 years. While each CP is unique, there are several general approaches to mitigation of incidental take:

- Reserves of various sizes, some associated with adjacent Federal reserves
- Forest management that maintains or develops nesting habitat
- Forest management that maintains or develops foraging habitat
- Forest management that maintains or develops dispersal habitat
- Deferral of harvest near specific sites

**Washington.** In Washington State, there are over 2.1 million acres of land in conservation plans (6 HCPs and 2 SHAs). Some of these CPs focus on providing nesting, roosting habitat throughout the area or in strategic locations; while others focus on providing connectivity through foraging habitat and/or dispersal habitat. Most of the Washington HCPs have foraging as a minimal target for habitat quality. In addition, there is a long-term habitat management agreement covering 13,000 acres in which authorization of take was provided through an incidental take statement (section 7) associated with a Federal land exchange.

Two Washington HCPs are based upon municipal watershed management and will provide older forest conditions over time. One HCP occurs within checkerboard ownership in the central Cascades and focuses on connectivity through a combination of nesting habitat in strategic locations as well as a distribution of nesting habitat and foraging habitat across the ownership and the planning area. Several HCPs, a Habitat Management Agreement (via section 7), and one safe harbor agreement focus on connectivity from a dispersal standpoint, including providing foraging habitat and landscape conditions conducive to spotted owl movement and potential residence. The largest HCP in Washington State (WDNR State lands) was designed by a scientific advisory team which analyzed the manner in which State lands could contribute to support the NWFP reserves. That HCP has a system of designated areas

designed to provide demographic support in some areas, and foraging and dispersal in other areas.

**Oregon.** The three spotted owl-related HCPs currently in effect cover more than 300,000 acres of non-federal lands. These HCPs are intended to provide some nesting habitat and connectivity over the next few decades. On July 27, 2010, the Service completed a Programmatic Safe Harbor Agreement with the Oregon Department of Forestry that will enroll up to 50,000 acres of non-federal lands within the State over a total of 50 years. It is primarily intended to increase the time between harvests (defer harvest), and to lightly to moderately thin younger forest stands that are currently not habitat to increase tree diameter size and stand diversity (species, canopy layers, presence of snags).

**California.** Four HCPs and 2 SHAs authorizing take of spotted owls have been approved; these CPs cover more than 622,000 acres of non-federal lands. Implementation of these plans is intended to provide for spotted owl demography and connectivity support to NWFP lands.

# Appendix B. Threats

## Habitat Changes

### Historical Levels of Spotted Owl Habitat and Rates of Loss

In 1990, the Service estimated spotted owl habitat had declined 60 to 88 percent since the early 1800s (USFWS 1990b). This loss, which was concentrated mostly at lower elevations and in the Coast Ranges, was attributed primarily to timber harvest and land-conversion activities, and to a lesser degree to natural perturbations (USFWS 1990a). Davis and Lint (2005) compared the current condition of forests throughout the range of the species to maps from the 1930s and 1940s and found that, in Oregon and Washington, fragmentation of forests had increased substantially; in some physiographic provinces, the increase was more than five-fold. However, fragmentation in California decreased, which the authors speculate may be due to fire suppression in fire-dependent provinces (Davis and Lint 2005).

### Recent Rates of Loss of Spotted Owl Habitat as a Result of Timber Harvest

Until 1990, the annual rate of removal of spotted owl habitat on national forests as a result of logging was approximately 1 percent per year in California and 1.5 percent per year in Oregon and Washington. Anticipated future rates of habitat removal on BLM lands in Oregon at that time were projected to eliminate all NRF habitat on non-protected BLM lands (except the Medford District) within 26 years (USFWS 1990b).

Since 1990, there have been only a few efforts that have produced indices or more direct estimates of trends or change in the amount of NRF habitat for spotted owls. Cohen *et al.* (2002) reported landscape-level changes in forest cover across the Pacific Northwest using remote sensing technology. Their study indicated, "a steep decline in harvest rates between the late 1980s and the early 1990s on State and Federal and private industrial forest lands" (as described in Bigley and Franklin 2004:6-11).

Recent data has become available through the NWFP monitoring efforts (Davis and Dugger in press). This information tracked changes in spotted owl nesting and roosting habitat across all ownerships from timber harvest and natural disturbances (wildfire, insects, and disease); it did not track all foraging habitat. Based on vegetation data, they produced maps of forest stands that compared the stand's level of similarity to stand conditions known to be used for nesting and roosting by spotted owls. These stands were placed into one of four

categories: highly suitable, suitable, marginal, and unsuitable. Highly suitable and suitable categories are likely nesting or roosting habitat, marginal stands may occasionally contain the habitat characteristics associated with nesting or roosting (see Davis and Dugger in press for more details). Data from California covered 14 years from 1994 to 2007, data from Oregon and Washington covered 10 years from 1996 to 2006 (Table B-1). Changes in habitat were evaluated comparing mapped differences in habitat condition between the initial and final vegetation maps. Habitat was considered "lost" if its condition moved from suitable or highly suitable to marginal or unsuitable.

Harvest rates for spotted owl nesting and roosting habitat on Federal lands were highest in the California Cascades (3.0 percent, 6,500 acres) and lowest in the Olympic Peninsula (0.06 percent, 500 acres). Overall, timber harvest on Federal lands removed 0.6 percent (53,800 acres) of nesting and roosting habitat during the reporting period.

**Table B-1.** Spotted owl habitat loss on Federal lands resulting from harvest and natural disturbances from 1994/96[1] to 2006-7[1] (acres) (adapted from Davis and Dugger in press).

| Physiographic Provinces | 1994/96 acres | Harvest (%)[2] | Natural Disturbance | | | Total Habitat Loss | Total Percent loss[2,3] |
|---|---|---|---|---|---|---|---|
| | | | Wildfire | Insects and disease | Total (%)[2] | | |
| Olympic Peninsula | 763,100 | **500 (0.06%)** | 200 | 0 | **200 (0.03%)** | 700 | **0.1%** |
| Eastern WA Cascades | 673,600 | **8,100 (1.2%)** | 20,000 | 2,000 | **22,000 (3.3%)** | 30,100 | **4.5%** |
| Western WA Cascades | 1,283,000 | **3,700 (0.3%)** | 700 | 400 | **1,100 (0.09%)** | 4,800 | **0.4%** |
| Western WA Lowlands | 24,700 | **400 (1.6%)** | 0 | 0 | **0** | 400 | **1.6%** |
| OR Coast Range | 611,200 | **3,300 (0.5%)** | 0 | 0 | **0** | 3,300 | **0.5%** |
| OR Klamath | 985,000 | **6,800 (0.7%)** | 93,600 | 300 | **93,900 (9.5%)** | 100,700 | **10.2%** |
| Eastern OR Cascades | 402,900 | **5,800 (1.4%)** | 17,800 | 2,300 | **20,100 (5.0%)** | 25,900 | **6.4%** |
| Western OR Cascades | 2,258,700 | **13,900 (0.6%)** | 28,900 | 1,100 | **30,000 (1.3%)** | 43,900 | **1.9%** |
| Willamette Valley | 3,400 | **100 (2.9%)** | 0 | 0 | **0** | 100 | **2.9%** |
| CA Coast | 145,400 | **300 (0.2%)** | 2,100 | 100 | **2,200 (1.5%)** | 2,500 | **1.7%** |
| CA Cascades | 213,200 | **6,500 (3.0%)** | 1,800 | 300 | **2,100 (1.0%)** | 8,600 | **4.0%** |
| CA Klamath | 1,489,800 | **4,400 (0.3%)** | 71,600 | 1,600 | **73,200 (4.9%)** | 77,600 | **5.2%** |
| **Range-wide total** | 8,853,000 | **53,800 (0.6%)** | 236,700 | 8,100 | **244,800 (2.8%)** | 298,600 | **3.4%** |

[1] 1996 and 2006 for Oregon and Washington, 1994 and 2007 for California.
[2] Percent of 1994/96 habitat.
[3] Loss is the term used in Davis and Dugger (in press) to describe their data, which is summarized here.

Raphael (2006) estimated that approximately 7.5 million acres of spotted owl habitat existed on non-federal lands within California, Oregon, and Washington

in 1994. Cohen *et al.* (2002) reported that, from the early 1970s through the mid-1990s, the harvest rates on private industrial lands were consistently about twice the average rate of harvest on public land. Bigley and Franklin (2004:6-11) noted that:

> "In the late 1980s and early 1990s the harvest rate was estimated at 2.4 percent per year for private industrial land. An increase in non-industrial private landowner's harvest rates started in the 1970s when the rate was 0.2 percent per year and continued to increase to the early 1990s when the rate was similar to that of the private industrial lands."

Recently, data on actual information on harvest of nesting and roosting habitat for non-federal lands became available through the NWFP monitoring program. On non-federal lands, 14.92 percent (625,600 acres) of the nesting and roosting habitat was harvested in the 10-14 years of the analysis. This compares to 0.6 percent (53,800 acres) on Federal lands in the same period.

**Table B-2.** Estimated amount of spotted owl nesting and roosting habitat1 at the start of the Northwest Forest Plan (baseline 1994/96[2]) and losses owing to harvest through 2006/7[2], by State and ownership (adapted from Davis and Dugger in press).

| Land class | Baseline (1994/96[2]) | Harvest | Total Percent loss[3] |
|---|---|---|---|
| **Federal reserved** | | | |
| Washington | 2,274,200 | 7,900 | 0.3% |
| Oregon | 2,699,600 | 6,100 | 0.2% |
| California | 1,214,000 | 2,500 | 0.2% |
| Range-wide total | **6,187,800** | **16,500** | **0.3%** |
| **Federal non-reserved** | | | |
| Washington | 470,200 | 4,800 | 1.0% |
| Oregon | 1,561,400 | 23,800 | 1.5% |
| California | 634,400 | 8,700 | 1.4% |
| Range-wide total | **2,666,000** | **37,300** | **1.4%** |
| **Non-federal** | | | |
| Washington | 1,258,900 | 234,200 | 18.6% |
| Oregon | 1,382,400 | 301,200 | 21.8% |
| California | 1,556,700 | 90,200 | 5.8% |
| Range-wide total | **4,198,000** | **625,600** | 14.9% |
| | | | |
| **Range-wide total** | **13,052,000** | **679,400** | **5.2%** |

[1] See Davis and Dugger (in press) for description of habitat.
[2] 1996 and 2006 for Oregon and Washington, 1994 and 2007 for California.
[3] Loss is the term used in Davis and Dugger (in press) to describe their data, which is summarized here.

# Recent Rates of Loss of NRF Habitat as a Result of Natural Events

The effects of wildfire and other natural disturbances on spotted owls and their habitat vary by location, severity, and habitat function, though most of the data is related specifically to fire. Spotted owl use of post fire habitat varies, depending on fire severity and the function of the site for spotted owls (*i.e.*, nesting, roosting, or foraging). Few studies are available to clarify this

relationship, and many of these are complicated by small sample sizes, post-fire logging, lack of long-term data, and inadequate pre-fire spotted owl data. Spotted owl reproduction and nesting have been observed in the short-term in some burned landscapes and even in core areas in which some portion was burned by high-severity fire. No nest trees were found in high-severity burns, though have been observed in moderate and low severity burned areas. Spotted owls have been observed roosting in forests experiencing the full range of fire severity, though most were associated with low or moderate severity burns. Spotted owls were observed to forage in burned areas within their home range in areas where dusky-footed woodrats are a primary food source, but there is no similar data in more northern conditions. Based on this information we conclude that, while spotted owls can make use of some post-fire landscapes, fire also reduces the function of some habitat and likely removes some from immediate usability, particularly in areas of high-severity fire.

Recent data from the NWFP Effectiveness Monitoring program provides an insight into the change in spotted owl nesting and roosting habitat from natural disturbances on Federal (Table B-1) and non-federal lands (Table B-3). Changes in habitat were evaluated comparing mapped differences in habitat condition over time. Habitat was considered "lost" if its condition moved from suitable or highly suitable to marginal or unsuitable. We use the term "loss" in this case because this is how the authors describe their data, though as described above, not all burned areas are necessarily lost as habitat. The level of losses varies widely by province, from extremely low (0.03percent of the nesting and roosting habitat) in the Olympic Peninsula Province to 9.5 percent in the Oregon Klamath Province. Wildfire caused most of the loss (236,700 acres) while insects and disease resulted in 8,100 acres of habitat. On non-federal lands, the level was very low, less than 1percent in each state (Table B-3).

**Table B-3.** Spotted owl nesting and roosting habitat loss from natural disturbances on non-federal lands from 1994/96[1] to 2006-7[1] (acres) (adapted from Davis and Dugger in press).

| State | 1994/96 habitat | Fire | Insects and disease | Total | Percent habitat loss[2] |
|---|---|---|---|---|---|
| Washington | 1,258,900 | 2,400 | 6,000 | 8,400 | 0.7% |
| Oregon | 1,382,400 | 5,100 | 2,700 | 7,800 | 0.6% |
| California | 1,556,700 | 5,600 | 1,900 | 7,500 | 0.4% |
| Total | 4,198,000 | 13,100 | 10,600 | 23,700 | 0.6% |

[1] 1996 and 2006 for Oregon and Washington, 1994 and 2007 for California.

[2] Loss is the term used in Davis and Dugger (in press) to describe their data, which is summarized here.

## Summary of Recent Rates of Loss of Spotted Owl Habitat as a Result of Timber Harvest and Natural Disturbances

Range-wide, 0.6 percent (53,800 acres) of the spotted owl nesting and roosting habitat on Federal lands were lost to timber harvest and 2.8 percent (244,800 acres) to natural disturbances, primarily wildfire, resulting in a total range-wide loss of 3.4 percent (298,600 acres). The greatest percentage of Federal land habitat loss was in Oregon, specifically in the Oregon Klamath Province (10.9 percent of the habitat) due primarily to wildfire. Two provinces, the Oregon and California Klamath accounted for 60 percent of the total habitat loss on Federal lands. In contrast, less than 1 percent of the nesting and roosting habitat in the Olympic Peninsula, Western Washington Cascades, and Oregon Coast Ranges were loss during the time period.

## Habitat Recruitment

Several groups have attempted to estimate the rate or amount of spotted owl habitat recruitment. Most of these estimates were not specific to spotted owl habitat. In reality, projecting the transition of a forest's age and size classes to different levels of habitat function requires extensive field verification. The SEI report (SEI 2004:6-29) provided a clear caution relative to habitat development.

> "Habitat development certainly is not a mechanistic process and there is considerable variability with predictions of habitat development. The habitat complexity that most definitions project as suitable habitat develops

over multiple decades and is not a threshold that is achieved with an average size class. Stand age or size does not account for the history, growing conditions, species composition, and other factors that determine the rate of habitat development. There is considerable uncertainty in the transition between mid-seral stage stands and suitable habitat. These uncertainties still exist with remote sensing information or inventory methods that are not specifically designed to sample the key components of suitable habitat."

In addition, determining when a forest progresses from non-habitat to habitat on an ecologically-short time frame (10-15 years) is fraught with assumptions and potential inaccuracy. Given the uncertainty about the rate of complex forest structure, it is likely that habitat development was overestimated, although the extent of overestimation cannot be determined (Bigley and Franklin 2004).

Given the degree of uncertainty, potential inaccuracy, and disagreements between results, we cannot at this time reach any conclusions on the issue of habitat recruitment. We will continue to follow this issue as new information becomes available.

## Disease

WNV has killed millions of wild birds in North America since it arrived in 1999 (McLean *et al.* 2001, Caffrey 2003, Fitzgerald *et al.* 2003, Marra *et al.* 2004). Mosquitoes are the primary carriers of this virus that causes encephalitis in humans, horses, and birds. Although birds are the primary hosts of WNV, additional non-human hosts include horses and other ungulates, felines, canines, rodents, rabbits, bats, alligators, and frogs (Hubálek and Halouzka 1999, Gubler 2007). Mammalian prey may play a role in spreading WNV, if predators like spotted owls contract the disease by eating infected prey (Garmendia *et al.* 2000, Komar *et al.* 2001). One captive spotted owl in Ontario, Canada, is known to have contracted WNV and died (Gancz *et al.* 2004), but there are no documented cases of the virus in wild spotted owls.

Health officials expect that WNV eventually will spread throughout the range of the spotted owl (Blakesley *et al.* 2004), but it is unknown how the virus will ultimately affect spotted owl populations. Susceptibility to infection and the mortality rates of infected individuals vary among bird species (Blakesley *et al.* 2004), but most owls appear to be quite susceptible. For example, eastern screech-owls breeding in Ohio that were exposed to WNV experienced 100 percent mortality (T. Grubb pers. comm. in Blakesley *et al.* 2004). Barred owls, in contrast, showed lower susceptibility (B. Hunter pers. comm. in Blakesley *et al.* 2004). Wild birds may develop resistance to WNV through immune responses (Deubel *et al.* 2001).

Blakesley *et al.* (2004) offer competing scenarios for the likely outcome of spotted owl populations being infected by WNV. One scenario is that spotted owls can tolerate severe, short-term population reductions caused by the virus because spotted owl populations are widely distributed and number in the several

thousands. An alternative scenario is that the virus will cause unsustainable mortality because of the frequency and/or magnitude of infection, thereby resulting in long-term population declines and extirpation from parts of the spotted owl's current range.

Ishak *et al.* (2008) document Plasmodium spp. in a spotted owl. They also found 10 spotted owls with multiple infections (Ishak *et al.* 2008). It is unclear, however, if this rate of infection is significant and if it might affect the recovery of the species.

# Inadequacy of Regulatory Mechanisms

The original listing document (USFWS 1990b), Franklin and Courtney (2004), and the 5-year review (USFWS 2004b) noted some inadequacies in existing regulatory mechanisms. The 1990 listing rule concluded that current State regulations and policies did not provide adequate protection for spotted owls; less than 1 percent of the non-federal lands provided long-term protection for spotted owls (USFWS 1990b). The listing rule stated that the rate of harvest on Federal lands, the limited amount of permanently reserved habitat, and the management of spotted owls based on a network of individually protected sites did not provide adequate protection for the spotted owl. If continued, these management practices would result in an estimated 60 percent decline in the remaining spotted owl habitat, and the resulting amount of habitat might not be sufficient to ensure long-term viability of the spotted owl.

When it was adopted in 1994, the NWFP significantly altered management of Federal lands (USDA and USDI 1994a, b, Noon and Blakesley 2006, Thomas *et al.* 2006). The substantial increase in reserved areas and associated reduced harvest (ranging from approximately 1 percent per year to 0.24 percent per year) has substantially lowered the timber-harvest threat to spotted owls. However, the NWFP allows some loss of habitat and assumed some unspecified level of continued decline in spotted owls. Franklin and Courtney (2004) noted that many, but not all, of the scientific building blocks of the NWFP have been confirmed or validated in the decade since the plan was adopted. One major limitation appears to be the inability of the conservation network presented in the plan to deal with invasive species. However, this deficiency does not diminish the important contribution of the relevant LRMPs to spotted owl conservation (Franklin and Courtney 2004).

As the Federal agencies develop new LRMPs, they will consider the conservation needs of the spotted owl and the goals and objectives of this Revised Recovery Plan. If needed, actions to implement Federal land use plans will be accompanied with either plan or project level consultations to assure management actions align with recovery goals.

# Barred Owls

Barred owls expanded their range from eastern to western North America during the past century. They were first documented in British Columbia in 1943 (Rand 1944, Munro and McTaggart-Cowan 1947), Washington in 1965 (Rogers 1966), Oregon in 1972 (E. Forsman in Livezey 2009a), California in 1976 (B. Marcot in Livezey 2009a). This range expansion may have been facilitated by increases in distribution of trees in the Great Plains due to exclusion of fires historically set by Native Americans, fire suppression, tree planting , extirpation of bison and beaver, and other factors (Dark *et al.* 1998, R. Gutiérrez in Levy 1999, 2004, Mazur and James 2000, USFWS 2003, Livezey 2009b). The range of the barred owl now completely overlaps that of its slightly smaller congener, the spotted owl (Gutiérrez *et al.* 1995).

Barred owls have been observed physically attacking spotted owls (pers. comms. in Pearson and Livezey 2003) and circumstantial evidence suggests that a barred owl killed a spotted owl (Leskiw and Gutiérrez 1998). Based on early studies conducted on the west slope of the Washington Cascades (Hamer 1988, Iverson 1993), barred owls were thought by some to be more closely associated with early successional forests than spotted owls are, though even then they were known to use old-growth. Recent studies in the Pacific Northwest (Herter and Hicks 2000, Pearson and Livezey 2003, Gremel 2005, Schmidt 2006, Hamer *et al.* 2007, Singleton *et al.* 2010) show that barred owls also use, and in some cases, appear to prefer old-growth forest and older forest. Diets of spotted and barred owls in the western Washington Cascades overlap by approximately 76 percent (Hamer *et al.* 2001). Barred owl diets are more diverse than those of spotted owls (Forsman *et al.* 2004) and include more species associated with riparian and other moist habitats, along with more terrestrial and diurnal species (Hamer *et al.* 2001). The more-diverse food habits of barred owls appears to be the reason that barred owls have much smaller home-ranges than spotted owls do (Hamer *et al.* 2007).

Barred owls reportedly have reduced probability of detection (response behavior), site occupancy, reproduction, and survival of spotted owls. The probability of detecting spotted owls during surveys in Washington, Oregon, and California was significantly reduced by the presence of barred owls (Olson *et al.* 2005, Crozier *et al.* 2006). In the eastern Cascades of Washington, probabilities of detecting any spotted owl or a pair of spotted owls were significantly lower when barred owls were detected during surveys than when no barred owls were detected (Kroll *et al.* 2010). In addition, studies in Oregon showed that detection of both species was negatively influenced by presence of the other (Bailey *et al.* 2009) and barred owls frequently were not detected during surveys for spotted owls (Bailey *et al.* 2009).

Forsman *et al.* (2011) and Anthony *et al.* (2006) have documented increasing barred owl numbers across Washington, Oregon, and California from 1990-2008. While barred owls have expanded into California more recently (Kelly *et al.* 2003), Forsman *et al.* (2011) provides strong evidence of increasing barred owl

populations in this region. Occupancy of territories by spotted owls in study areas in Washington and Oregon was significantly lower after barred owls were detected within 0.5 miles of the territory center but was "only marginally lower" if barred owls were located more than 0.5 miles from the spotted owl territory center (Kelly *et al.* 2003:51). In the Gifford Pinchot National Forest, there were significantly more barred owl site-centers in unoccupied spotted owl circles than in occupied spotted owl circles with radii of 0.5 miles, 1 mile, and 1.8 miles centered on spotted owl sites (Pearson and Livezey 2003). In the eastern Washington Cascades, barred owls had a significant negative effect on site occupancy by any spotted owl (both single and pair spotted owl detections combined); however, barred owls did not have a negative effect on site occupancy by spotted owl pairs (Kroll *et al.* 2010). Spotted owl simple extinction probabilities (probability that a site center changed from occupied to unoccupied) were significantly higher in the eastern Washington Cascades when barred owls were detected in a site center during the year (Kroll *et al.* 2010). In Olympic National Park, spotted owl pair occupancy declined significantly at sites where barred owls had been detected, whereas pair occupancy remained stable at spotted owl sites without barred owls (Gremel 2005). Annual probability that a spotted owl territory would be occupied by a pair of spotted owls after barred owls were detected at the site declined by five percent in the HJ Andrews study area, 12 percent in the Coast Range study area, and 15 percent in the Tyee study area (Olson *et al.* 2005).

Barred owls evidently are appropriating spotted owl sites in flatter, lower-elevation forests in some areas (Pearson and Livezey 2003, Gremel 2005, Hamer *et al.* 2007). Apparently in response to barred owls, some marked spotted owl site centers have moved higher up slopes (Gremel 2005). According to one study, "the trade-off for living in high elevation forests could be reduced survival or fecundity in years with severe winters (Hamer *et al.* 2007:764)." It is unknown whether this slope/elevation tendency found in Washington is prevalent throughout the range of the spotted owl, how long spotted owls can persist where they are relegated to only steep, higher-elevation areas, and whether barred owls will continue to move upslope and eventually supplant the remaining spotted owls in these areas.

Reproduction of spotted owls in the Roseburg study area, Oregon, was negatively affected by the presence of barred owls (Olson *et al.* 2004). Apparent survival of spotted owls was negatively affected by barred owls in two (Olympic and Wenatchee) of 14 study areas throughout the range of the spotted owl (Anthony *et al.* 2006). The researchers attributed the equivocal results for most of their study areas to the coarse nature of their barred owl covariate. It is likely that this study underestimated the effects of barred owls on the reproduction of spotted owls because spotted owls often cannot be relocated after they are displaced by barred owls (E. Forsman pers. comm. 2006).

Only 47 spotted owl/barred owl hybrids were detected in an analysis of more than 9,000 banded spotted owls throughout their range (Kelly and Forsman 2004). Consequently, hybridization with the barred owl is considered to be "an interesting biological phenomenon that is probably inconsequential, compared

with the real threat—direct competition between the two species for food and space" (Kelly and Forsman 2004:808).

Data indicating negative effects of barred owls on spotted owls are largely correlational and are almost exclusively gathered incidentally to data collected on spotted owls (Gutiérrez *et al.* 2004, Livezey and Fleming 2007). Competition theory predicts that barred owls will compete with spotted owls because they are similar in size and have overlapping diet and habitat requirements (Hamer *et al.* 2001, 2007, Gutiérrez *et al.* 2007). Limited experimental evidence (Crozier *et al.* 2006), preliminary response by spotted owls to a scientific collection of barred owls (L. Diller pers. comm. 2010), correlational studies (Kelly *et al.* 2003, Pearson and Livezey 2003, Gremel 2005, Olson *et al.* 2005, Hamer *et al.* 2007, Dugger *et al.* in press), and anecdotal information (Leskiw and Gutiérrez 1998, Gutiérrez *et al.* 2004) suggest that barred owls are negatively affecting spotted owls through exploitive and interference competition. The preponderance of evidence suggests barred owls are contributing to the population decline of spotted owls, especially in Washington, portions of Oregon, and the northern coast of California (Gutiérrez *et al.* 2004, Olson *et al.* 2005) which may explain the sharper decline in the spotted owl population trend in the northern portion of the spotted owl's range compared to those in the southern portion of the range.

# Loss of Genetic Variation

One possible threat to spotted owls is a loss of genetic variation from population bottlenecks which could lead to increased inbreeding depression and decreased adaptive potential. Funk *et al.* (2010) found evidence of recent genetic bottlenecks in the spotted owl population, estimating these have occurred within the last few decades. They found the strongest evidence for recent bottlenecks in the Washington Cascades, which they correlate with data on significant population declines in the same area. However, they did not find strong evidence of bottlenecks in other areas that showed population declines. While they could not determine "whether inbreeding is contributing to vital rate reductions" (pg. 7), they do caution that "future efforts to conserve northern spotted owl populations will require greater consideration of genetic threats to persistence" (pg. 7).

SEI (2008) reviewed a presentation and two unpublished manuscripts, provided by Dr. Susan Haig, on the evidence for genetic bottlenecks in spotted owl populations. Using microsatellite markers and a computer program called "Bottleneck," Haig provided evidence of recent genetic bottlenecks at several spatial scales (individual "populations" [demographic study areas], regions, and subspecies). Haig explicitly stated she could not conclude these bottlenecks were the cause for, nor were they necessarily related to, the recently documented declines in spotted owl populations. However, she did present a "cross-walk" of her results with a table depicting the status of spotted owl populations from Anthony *et al.* (2006).

SEI (2008) concluded Haig's observed bottlenecks are likely the result of population declines and not the cause of it; they are signatures of something that occurred in the past. SEI (2008) advises the population dynamics of the spotted owl likely will be more important to its short-term survival than will be its genetic makeup, regardless of the evidence for bottlenecks having occurred in the past (Barrowclough and Coats 1985).

# Appendix C. Development of a Modeling Framework to Support Recovery Implementation and Habitat Conservation Planning

**Introduction by U.S. Fish and Wildlife Service**

The Service believes a spatially explicit demographic model would greatly improve recovery planning and implementation for the spotted owl. Peer reviewers were critical of the 2008 Recovery Plan's habitat conservation network strategy and the general lack of updated habitat modeling capacity. The Service considered this criticism and concluded that a spatially explicit demographic model would greatly improve recovery implementation for the spotted owl, as well as other land use management decisions.

For this Revised Recovery Plan, the Service appointed a team of experts to develop and test a modeling framework that can be used in numerous spotted owl management decisions. This spatially-explicit approach is designed to allow for a more in-depth evaluation of various factors that affect spotted owl distribution and populations**.** This approach also allows for a unique opportunity to integrate new data sets, such as information from the NWFP 15-year Monitoring Report (Davis and Dugger in press) and the recent spotted owl population meta-analysis (Forsman *et al.* 2011).

The Service expects this modeling framework will be applied by Federal, State, and private scientists to make better informed decisions concerning what areas should be conserved or managed to achieve spotted owl recovery. Specifically, the modeling framework can be applied to various spotted owl management challenges, such as to:

1) Inform evaluations of meeting population goals and Recovery Criteria.
2) Develop reliable analysis and modeling tools to enable evaluation of the influence of habitat suitability and barred owls on spotted owl demographics.
3) Support future implementation and evaluation of the efficacy of spotted owl conservation measures described in various recovery actions.
4) Provide a framework for landscape-scale planning by both Federal and non-federal land managers that enables evaluation of potential demographic responses to various habitat conservation scenarios, including information that could be used in developing a proposed critical habitat rule.

These and other potential applications of the modeling framework described herein represent a significant advancement in spotted owl recovery planning. Although the completed model framework will be included in the Revised Recovery Plan, the Service hopes that future application of this modeling approach will lead to refinement and improvements, such as incorporation of population connectivity and source-sink dynamics, over time as experience and new scientific insights are realized.

To meet these objectives, the Service established the Spotted Owl Modeling Team (hereafter the "modeling team") to develop and apply modeling tools for the Service's use in designing and evaluating various conservation options for achieving spotted owl recovery. The modeling team was informally organized along lines of function and level of participation. Jeffrey Dunk (Humboldt State University), Brian Woodbridge (USFWS), Bruce Marcot (USFS, Pacific Northwest Research Station), Nathan Schumaker (USEPA), and Dave LaPlante (a contractor with Natural Resource Geospatial) composed the primary group which was responsible for conducting the data analyses and modeling. They were assisted by spotted owl researchers, agency staff and modeling specialists who individually provided data sets and advice on particular issues within their areas of expertise, and reviewed modeling processes and outputs. These experts were: Robert Anthony (Oregon State University), Katie Dugger (Oregon State University), Marty Raphael (USFS, Pacific Northwest Research Station), Jim Thrailkill (USFWS), Ray Davis (USFS, Northwest Forest Plan Monitoring Group), Eric Greenquist (BLM), and Brendan White (USFWS). Additionally, technical specialists—Craig Ducey (BLM), Karen West (USFWS) and Dan Hansen and M.J. Mazurek (contractors with Humboldt State University Foundation) conducted literature reviews and assisted with data collection and analyses.

To ensure that the modeling effort was based on the most current information, scientific knowledge and opinion, the modeling team also sought the assistance of numerous individual scientists and habitat managers from government, industry and a non-profit conservation organization (listed in acknowledgements) in development of habitat descriptions, modeling regions and many other aspects of spotted owl and forest ecology. To facilitate this effort, the Service held a series of meetings with spotted owl experts (habitat expert panels) to obtain additional information, data sets, and expertise regarding spotted owl habitats.

Representatives of the modeling team have prepared this Appendix to provide a thorough description of the modeling framework developed by the team, the results of model development and testing, and examples of how the modeling process can be used to evaluate habitat conservation scenarios and their relative contribution to recovery.

While this framework represents state-of-the-art science, it is not intended to represent absolute spotted owl population numbers or be a perfect reflection of reality. Instead, it provides a comparison of the relative spotted owl responses to a variety of potential conservation measures and habitat conservation networks. The implementation of spotted owl recovery actions should consider the results

of the modeling framework as one of numerous sources of information to be incorporated into the decision-making process.

**General Approach**

The spotted owl modeling team (hereafter "modeling team" or "we") employed state-of–the-art modeling tools in a multi-step analysis similar to that proposed by Heinrichs *et al.* (2010) and Reed *et al.* (2006) for designing habitat conservation networks and evaluating their contributions to spotted owl recovery. In addition to this objective, the modeling tools in this framework, individually or in combination, are designed to enable evaluation of the efficacy of spotted owl conservation measures such as Recovery Action 10 and management of barred owls**.**

Our conservation planning framework integrates a spotted owl habitat model, a habitat conservation planning model, and a population simulation model. Collectively, these modeling tools allow comparison of estimated spotted owl population performance among alternative habitat conservation network scenarios under a variety of potential conditions. This will enable the Service and other interested managers to use relative population viability (timing and probability of population recovery) as a criterion for evaluating habitat conservation network scenarios and other conservation measures for the spotted owl.

The evaluation approach the modeling team developed consists of three main steps (Figure C1):

> **Step 1** – Create a map of spotted owl habitat suitability throughout the species' U.S. range, based on a statistical model of spotted owl habitat associations.
>
> **Step 2** – Develop a spotted owl conservation planning model, based on the habitat suitability model developed in Step 1, and use it to design an array of habitat conservation network scenarios.
>
> **Step 3** – Develop a spatially explicit spotted owl population model that reliably predicts relative responses of spotted owls to environmental conditions, and use it to test the effectiveness of habitat conservation network scenarios designed in step 2 in recovering the spotted owl. The simulations from this spotted owl population model are not meant to be estimates of what will occur in the future, but provide information on trends predicted to occur under differing habitat conservation scenarios.

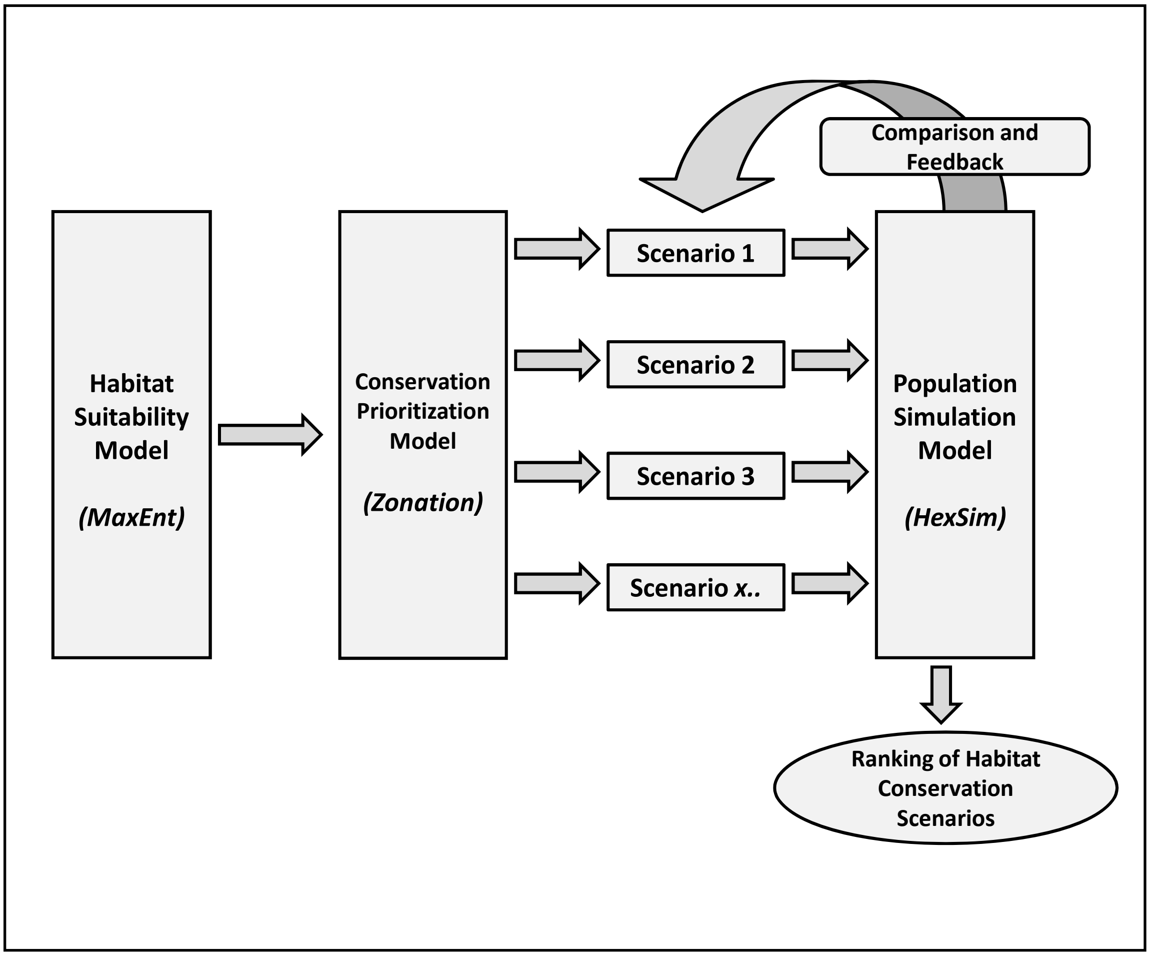
The Service or other practitioners can use the population simulation model developed in Step 3 to test the degree to which various recovery actions and habitat conservation network scenarios contribute to recovery of the spotted owl. For example, it can be used to evaluate relative population size and trend, as well as distribution and connectivity of modeled spotted owl populations through time.

Each of the steps noted above involved statistical and/or mathematical modeling and is not meant to be exact predictions of what currently exists or what will occur in the future, but represent our best estimates of current conditions and relationships. These models allow the use of powerful, up-to-date scientific tools in a repeatable and scientifically accepted manner to develop and evaluate habitat conservation networks and other conservation measures to recover the spotted owl. We view the benefit and utility of such models in the same way that Johnson (2001) articulated, "*A model has value if it provides better insight, predictions, or control than would be available without the model*." The modeling tools described herein meet this standard.

The overall framework and evaluations outlined in Figure C1 are somewhat similar to Raphael *et al.* (1998). Our modeling process differs fundamentally from the conservation planning approach used by the ISC (Thomas *et al*. 1990), 1992 Draft Recovery Plan (USFWS 1992b), FEMAT (1993), and the 2008 Recovery plan (USFWS 2008b), which were based on *a priori* rule sets derived from best expert judgment regarding the size of reserves or habitat conservation blocks, target number of spotted owl pairs per reserve or block, and targeted spacing between reserves or blocks. The new modeling framework we developed instead uses a series of spatially explicit modeling processes to develop habitat conservation networks (or "reserves") based on the distribution of habitat value. Issues of habitat connectivity and population isolation are identified within the population simulation model outputs.

The spotted owl modeling team has completed the development and evaluation of the overall modeling framework described in Steps 1 through 3 above. The *use* of the modeling framework, for example, to inform design and evaluation of various habitat conservation network scenarios (including potential effects of barred owl management), other conservation measures described in recovery actions, and evaluate potential effects of climate change will be completed as a part of recovery plan implementation or other analytical and regulatory processes.

**Figure C-1. Diagram of stepwise modeling process for developing and evaluating habitat conservation scenarios for the spotted owl.**




## Modeling Process Step 1 – Create a spotted owl habitat suitability map covering the U.S. range of the subspecies based on a statistical model of spotted owl habitat associations.

**Habitat modeling objective and overall approach:**

A variety of methods are available for modeling species-habitat relationships (Morrison *et al.* 1992, Elith *et al.* 2006), with divergent assumptions and underlying statistical bases (Breiman 2001). The selection of a modeling tool is influenced foremost by the objectives of the modeling exercise, and by the characteristics of data available for modeling. The primary objective of our recovery plan modeling was to develop a map that reliably predicts relative habitat suitability for the spotted owl. Our primary goals were to develop predictive models that: 1) had good discriminatory ability, 2) were well calibrated, 3) were robust, and 4) had good generality. Our modeling was not an

attempt to quantify or refine our understanding of the spotted owl's niche; but instead focused on predictions. Because we were primarily focused on obtaining reliable predictions, we were less concerned about covariates and their associated parameter estimates, or the relative importance of each habitat variable. This objective enabled us to consider newer algorithmic modeling approaches that emphasize prediction (Breiman 2001).

The nature of the spotted owl data available to us also influenced our choice of a modeling approach. We gathered several datasets which resulted in a large number of spotted owl locations, but only a relatively small subset of those data sets also had survey effort information (that could be used for occupancy modeling) and absence data (locations that were adequately sampled and where spotted owls were not detected). Because the majority of spotted owl data available was best characterized as 'presence-only' data, we elected not to employ occupancy modeling approaches.

Our objectives and the nature of the data available to us lead us to choose the species distribution model MaxEnt (Phillips *et al*. 2006, Phillips and Dudik 2008) to model spotted owl relative habitat suitability. MaxEnt is specifically designed for presence-only data. Moreover, MaxEnt has been thoroughly evaluated on a number of taxa, geographic regions, and sample sizes and has been found to perform extremely well (Elith *et al.* 2006, Wisz *et al*. 2008).

**Distributional Models and the Spotted Owl:**

Species distributional models are used to evaluate species-habitat relationships, evaluate an area's suitability for the species, and to predict a species' presence (Elith and Leathwick 2009). These models, also called environmental (or ecological) niche models, correlate environmental conditions with species distribution and thereby predict the relative suitability of habitat within some geographic area (Warren and Seifert 2011). When translated into maps depicting the spatial distribution of predicted habitat suitability, these models have great utility for evaluating conservation reserve design and function (Zabel *et al.* 2002, Zabel *et al*. 2003, Carroll and Johnson 2008, Carroll *et al.* 2010). Because the spotted owl is one of the most studied raptors in the world; we had available hundreds of peer-reviewed papers on various aspects of the species' ecology, including habitat use and selection (see reviews by Gutiérrez *et al.* 1995, Blakesley 2004). Only a few range-wide (in the U.S.) evaluations of habitat association (Carroll and Johnson 2008) or habitat distribution (Davis and Lint 2005, Davis and Dugger in press) have been conducted. While we capitalized on this large body of literature and other information to build models for conservation planning purposes, we were primarily interested in using such models to map relative habitat suitability rather than to provide new ecological understanding of spotted owl habitat associations.

**Meetings with spotted owl habitat experts and review of literature and data sets:**

Because the spotted owl is among the most-studied birds in the world, there is a wealth of information on its ecology and habitat associations. To ensure that the modeling effort was based on this scientific foundation, our first step was to conduct an extensive review of published and unpublished information on the species. Concurrent with this effort, team members travelled throughout the spotted owl's range and met with researchers and biologists with extensive experience studying spotted owls. Some of these meetings were one-on-one, and at other times we held meetings with several experts at one time to seek their individual advice. We have sometimes referred to these meetings as "expert panels." At these meetings, biologists were each asked to identify (1) the environmental factors to which spotted owls respond within particular physiographic provinces (*e.g.* Klamath Mountains of southern Oregon and northern California, Olympic Peninsula, Redwood Coast), and (2) regions believed to be distinct where spotted owls may be responding to conditions uniquely. In order to identify distinct modeling areas and definitions of spotted owl habitat (see below), we used both empirical findings (*i.e.*, published information) and the professional judgment of spotted owl experts.

**Modeling regions - Partitioning the species' range:**

Several authors have noted that spotted owls exhibit different habitat associations in different portions of their range, which is often attributed to regional differences in forest environments and factors such as important prey species (Carey *et al.* 1992, Franklin *et al.* 2000, Noon and Franklin 2002, Zabel *et al.* 2003), or presence of Douglas-fir dwarf mistletoe (expert panels). The distribution of these features is likely influenced by relatively large east-west and north-south gradients in ecological conditions (*e.g.*, temperature, precipitation, net primary productivity) and subsequent variation in forest environments. Hence, we developed and evaluated region-specific habitat suitability models under the assumption that spotted owls *within* a modeling region respond to habitat conditions more similarly than do spotted owls *between* modeling regions where conditions differ.

For monitoring, management and regulatory purposes, the spotted owl's range has historically been divided into 12 physiographic provinces (USDI 1992, Davis and Lint 2005) based largely on the regional distribution of major forest types and state boundaries. Based on differences and similarities in spotted owl habitat, we combined some provinces (California and Oregon Klamath provinces), retained others, and divided some provinces into smaller modeling regions (see Figure C2). We did not establish modeling regions or develop models for the Puget Lowlands, Southwestern Washington, and Willamette Valley, where spotted owls are almost completely absent and sample sizes were too small to support for model development. Instead, we projected the models developed for the closest adjacent area to those areas. This decision had the

influence of allowing those regions to have at least some potential value to simulated spotted owls as opposed to assuming zero value.

The predictive ability and accuracy of habitat suitability models are influenced by the range of environmental conditions that are incorporated into the training data used in model development. Models developed from data sets encompassing broad environmental gradients tend to be overly general; conversely, models developed with data representing a small subset of conditions have limited applicability across the species' larger distribution. The practice of partitioning a species' range into "modeling regions" that encompass relatively dissimilar subsets of species-habitat relationships and developing models specific to each region was used to reduce this source of variability. The challenge is balancing the high degree of variability within large regions against the tendency to create many small modeling regions (with potentially small sample sizes) based on locally unique environmental conditions.

We queried experts to suggest potential modeling region boundaries, and they provided input on broad-scale patterns in climate, topography, forest communities, spotted owl habitat relationships, and prey-base that supported delineation of the draft spotted owl modeling regions (Figure C2). Franklin and Dyrness (1973), Kuchler (1977) and other published sources of information on the distribution of major ecological boundaries were also consulted. Using information provided through our discussions with the expert panels and existing ecological section and subsection boundaries (McNab and Avers 1994), we delineated 11 spotted owl modeling regions (Figure C2).

In general, the spotted owl modeling regions varied in terms of these ecological features:

1) Degree of similarity between structural characteristics of habitats used by spotted owls primarily for nesting/roosting and habitats used for foraging and other nocturnal activities. This similarity is largely influenced by habitat characteristics of the spotted owl's dominant prey (proportion of flying squirrels versus woodrats).
2) Latitudinal patterns of topography and climate. For example, in the WA Cascades, spotted owls are rarely found at elevations above 1,219-1,372 m, whereas in southern Oregon and the Klamath province spotted owls commonly reside up to 1,830 m.
3) Regional patterns of topography, climate, and forest communities.
4) Geographic distributions of habitat elements that influence the range of conditions occupied by spotted owls. For example, several panelists pointed out that the distribution of dwarf mistletoe influences the range of stand structural values associated with spotted owl use. Other examples include the geographic distribution of elements such as evergreen hardwoods, Oregon white oak woodlands, and ponderosa pine-dominated forests.

**Modeling Region Descriptions:**

**North Coast Ranges and Olympic Peninsula (NCO):** This region consists of the Oregon and Washington Coast Ranges Section M242A (McNab and Avers 1994). This region is characterized by high rainfall, cool to moderate temperatures, and generally low topography (448 to 750 m). High elevations and cold temperatures occur in the interior portions of the Olympic Peninsula, but spotted owls in this area are limited to the lower elevations (<900 m.). Forests in the NCO are dominated by western hemlock, Sitka spruce, Douglas-fir, and western red cedar. Hardwoods are limited in species diversity (consist mostly of bigleaf maple and red alder) and distribution within this region, and typically occur in riparian zones. Root pathogens like laminated root rot (*Phellinus weirii*) are important gap formers, and vine maple, among others, fills these gaps. Because Douglas-fir dwarf mistletoe is unusual in this region, spotted owl nesting habitat consists of stands providing very large trees with cavities or deformities. A few nests are associated with western hemlock dwarf mistletoe. Spotted owl diets are dominated by species associated with mature to late-successional forests (flying squirrels, red tree voles), resulting in similar definitions of habitats used for nesting/roosting and foraging by spotted owls. This region contains the Olympic Demographic Study Area (DSA).

**Oregon Coast Ranges (OCR):** This region consists of the southern 1/3 of the Oregon and Washington Coast Ranges Section M242A (McNab and Avers 1994). We split the section in the vicinity of Otter Rock, OR, based on gradients of increased temperature and decreased moisture that result in different patterns of vegetation to the south. Generally this region is characterized by high rainfall, cool to moderate temperatures, and generally low topography (300 to 750 m.). Forests in this region are dominated by western hemlock, Sitka spruce, and Douglas-fir; hardwoods are limited in species diversity (largely bigleaf maple and red alder) and distribution, and are typically limited to riparian zones. Douglas-fir and hardwood species associated with the California Floristic Province (tanoak, Pacific madrone, black oak, giant chinquapin) increase toward the southern end of the OCR. On the eastern side of the Coast Ranges crest, habitats tend to be drier and dominated by Douglas-fir. Root pathogens like laminated root rot (*P. weirii*) are important gap formers, and vine maple among others fills these gaps. Because Douglas-fir dwarf mistletoe is unusual in this region, spotted owl nesting habitat tends to be limited to stands providing very large trees with cavities or deformities. A few nests are associated with western hemlock dwarf mistletoe. Spotted owl diets are dominated by species associated with mature to late-successional forests (flying squirrels, red tree voles), resulting in similar definitions of habitats used for nesting/roosting and foraging by spotted owls. One significant difference between OCR and NCO is that woodrats comprise an increasing proportion of the diet in the southern portion of the modeling region. This region contains the Tyee and Oregon Coast Range DSAs.

**Redwood Coast (RDC):** This region consists of the Northern California Coast Ecological Section 263 (McNab and Avers 1994). This region is characterized by

low-lying terrain (0 to 900 m.) with a maritime climate; generally mesic conditions and moderate temperatures. Climatic conditions are rarely limiting to spotted owls at all elevations. Forest communities are dominated by redwood, Douglas-fir-tanoak forest, coast liveoak, and tanoak series. The vast majority of the region is in private ownership, dominated by a few large industrial timberland holdings. The results of numerous studies of spotted owl habitat relationships suggest stump-sprouting and rapid growth rates of redwoods, combined with high availability of woodrats in patchy, intensively-managed forests, enables spotted owls to maintain high densities in a wide range of habitat conditions within the Redwood zone. This modeling region contains the Green Diamond and Marin DSAs.

**Western Cascades North (WCN):** This region generally coincides with the northern Western Cascades Section M242B (McNab and Avers 1994), combined with western portion of M242D (Northern Cascades Section), extending from the U.S. - Canadian border south to Snoqualmie Pass in central Washington. It is similar to the Northern Cascades Province of Franklin and Dyrness (1974). This region is characterized by high mountainous terrain with extensive areas of glaciers and snowfields at higher elevation. The marine climate brings high precipitation (both annual and summer) but is modified by high elevations and low temperatures over much of this modeling region. The resulting distribution of forest vegetation is dominated by subalpine species, mountain hemlock and silver fir; the western hemlock and Douglas-fir forests typically used by spotted owls are more limited to lower elevations and river valleys (spotted owls are rarely found at elevations greater than 1,280 m. in this region) grading into the mesic Puget lowland to the west. Root pathogens like laminated root rot (*P. weirii*) are important gap formers, and vine maple, among others, fills these gaps. Because Douglas-fir dwarf mistletoe occurs rarely in this region, spotted owl nests sites are limited to defects in large trees, and occasionally nests of other raptors. Diets of spotted owls in this northern region contain higher proportions of red-backed voles and deer mice than in the region to the south, where flying squirrels are dominant (expert panels). There are no Demographic Study Areas in this modeling region.

**Western Cascades Central (WCC):** This region consists of the midsection of the Western Cascades Section M242B (McNab and Avers 1994), extending from Snoqualmie Pass in central Washington south to the Columbia River. It is similar to the Southern Washington Cascades Province of Franklin and Dyrness (1974). We separated this region from the northern section based on differences is spotted owl habitat due to relatively milder temperatures, lower elevations, and greater proportion of western hemlock/Douglas-fir forest and occurrence of noble fir to the south of Snoqualmie Pass. Because Douglas-fir dwarf mistletoe occurs rarely in this region, spotted owl nest sites are largely limited to defects in large trees, and occasionally nests of other raptors. This region contains the Rainier DSA and small portions of the Wenatchee and Cle Elum DSAs.

**Western Cascades South (WCS):** This region consists of the southern portion of the Western Cascades Section M242B (McNab and Avers 1994) and extends from the Columbia River south to the North Umpqua River. We separated this region from the northern section due to its relatively milder temperatures, reduced summer precipitation due to the influence of the Willamette Valley to the west, lower elevations, and greater proportion of western hemlock/Douglas-fir forest. The southern portion of this region exhibits a gradient between Douglas-fir/western hemlock and increasing Klamath-like vegetation (mixed conifer/evergreen hardwoods) which continues across the Umpqua divide area. The southern boundary of this region is novel and reflects a transition to mixed conifer sensu Franklin and Dyrness (1974). The importance of Douglas-fir dwarf mistletoe increases to the south in this region, but most spotted owl nest sites in defective large trees, and occasionally nests of other raptors. The HJ Andrews DSA occurs within this modeling region.

**Eastern Cascades North (ECN):** This region consists of the eastern slopes of the Cascade range, extending from the Canadian border south to the Deschutes National Forest near Bend, OR. Terrain in portions of this region is glaciated and steeply dissected. This region is characterized by a continental climate (cold, snowy winters and dry summers) and a high-frequency/low-mixed severity fire regime. Increased precipitation from marine air passing east through Snoqualmie Pass and the Columbia River results in extensions of moist forest conditions into this region (Hessburg *et al.* 2000b). Forest composition, particularly the presence of grand fir and western larch, distinguishes this modeling region from the southern section of the eastern Cascades. While ponderosa pine forest dominates lower and middle elevations in both this and the southern section, the northern section supports grand fir and Douglas fir habitat at middle elevations. Dwarf mistletoe provides an important component of nesting habitat, enabling spotted owls to nest within stands of relatively younger, small trees. This modeling region contains the Wenatchee and Cle Elum DSAs.

**Eastern Cascades South (ECS):** This region incorporates the Southern Cascades Ecological Section M261D (McNab and Avers 1994) and the eastern slopes of the Cascades from the Crescent Ranger District of the Deschutes National Forest south to the Shasta area. Topography is gentler and less dissected than the glaciated northern section of the eastern Cascades. A large expanse of recent volcanic soils (pumice region: Franklin and Dyrness 1974), large areas of lodgepole pine, and increasing presence of red fir and white fir (and decreasing grand fir) along a south-trending gradient further supported separation of this region from the northern portion of the eastern Cascades. This region is characterized by a continental climate (cold, snowy winters and dry summers) and a high-frequency/low-mixed severity fire regime. Ponderosa pine is a dominant forest type at mid-to lower elevations, with a narrow band of Douglas-fir and white fir at middle elevations providing the majority of spotted owl habitat. Dwarf mistletoe provides an important component of nesting habitat, enabling spotted owls to nest within stands of relatively younger, smaller trees.

The Warm Springs DSA and eastern half of the South Cascades DSA occur in this modeling region.

**Western Klamath Region (KLW):** This region consists of the western portion of the Klamath Mountains Ecological Section M261A (McNab and Avers 1994). A long north-south trending system of mountains (particularly South Fork Mountain) creates a rainshadow effect that separates this region from more mesic conditions to the west. This region is characterized by very high climatic and vegetative diversity resulting from steep gradients of elevation, dissected topography, and the influence of marine air (relatively high potential precipitation). These conditions support a highly diverse mix of mesic forest communities such as Pacific Douglas-fir, Douglas-fir tanoak, and mixed evergreen forest interspersed with more xeric forest types. Overall, the distribution of tanoak is a dominant factor distinguishing the Western Klamath Region. Douglas-fir dwarf mistletoe is uncommon and seldom used for nesting platforms by spotted owls. The prey base of spotted owls within the Western Klamath is diverse, but dominated by woodrats and flying squirrels. This region contains the Willow Creek, Hoopa, and the western half of the Oregon Klamath DSAs.

**Eastern Klamath Region (KLE):** This composite region consists of the eastern portion of the Klamath Mountains Ecological Section M261A (McNab and Avers 1994) and portions of the Southern Cascades Ecological Section M261D in Oregon. This region is characterized by a Mediterranean climate, greatly reduced influence of marine air, and steep, dissected terrain. Franklin and Dyrness (1974) differentiate the mixed conifer forest occurring on the "Cascade side of the Klamath from the more mesic mixed evergreen forests on the western portion (Siskiyou Mountains), and Kuchler (1977) separates out the eastern Klamath based on increased occurrence of ponderosa pine. The mixed conifer/evergreen hardwood forest types typical of the Klamath region extend into the southern Cascades in the vicinity of Roseburg and the North Umpqua River, where they grade into the western hemlock forest typical of the Cascades. High summer temperatures and a mosaic of open forest conditions and Oregon white oak woodlands act to influence spotted owl distribution in this region. Spotted owls occur at elevations up to 1,768 m. Dwarf mistletoe provides an important component of nesting habitat, enabling spotted owls to nest within stands of relatively younger, small trees. The western half of the South Cascades DSA and the eastern half of the Klamath DSA are located within this modeling region.

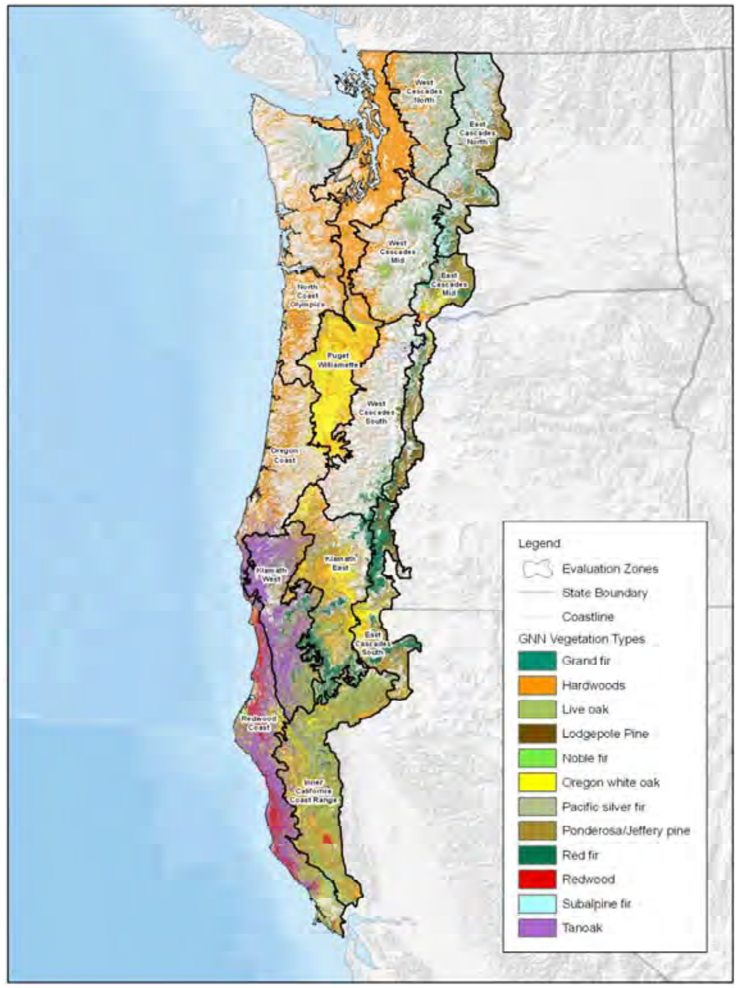
**Northern California Interior Coast Ranges Region (ICC):** This region consists of the Northern California Coast Ranges ecological Section M261B (McNab and Avers 1994), and differs markedly from the adjacent redwood coast region. Marine air moderates winter climate, but precipitation is limited by rainshadow effects from steep elevational gradients (100 to 2,400 m.) along a series of north-south trending mountain ridges. Due to the influence of the adjacent Central Valley, summer temperatures in the interior portions of this region are among the highest within the spotted owl's range. Forest communities tend to be relatively dry mixed conifer, blue and Oregon white oak, and the Douglas-fir-

tanoak series. Spotted owl habitat within this region is poorly known; there are no DSAs and few studies have been conducted here. Spotted owl habitat data obtained during this project suggests that some spotted owls occupy steep canyons dominated by liveoak and Douglas-fir; the distribution of dense conifer habitats is limited to higher-elevations on the Mendocino National Forest.

**Figure C-2**. Modeling regions used in development of relative habitat suitability models for the spotted owl.

# Modeling Regions

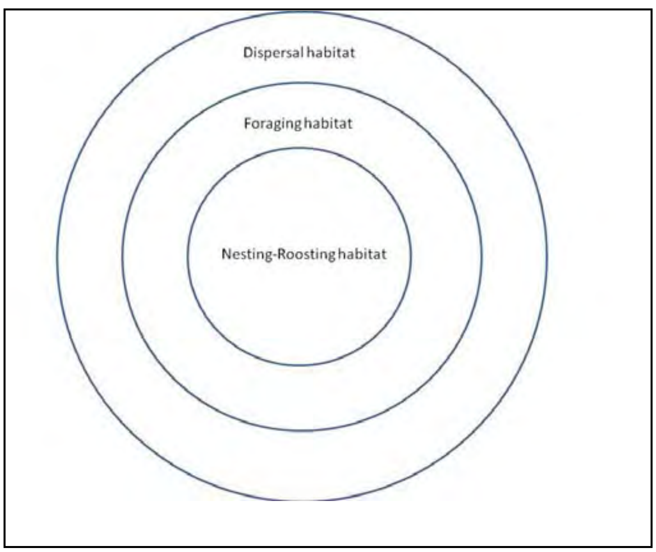
| **CODE** | **Description** |
|---|---|
| **NCO** | **North Coast and Olympic** |
| **OCR** | **Oregon Coast** |
| **RDC** | **Redwood Coast** |
| **WCN** | **Western Cascades - North** |
| **WCC** | **Western Cascades - Central** |
| **WCS** | **Western Cascades - South** |
| **ECN** | **Eastern Cascades - North** |
| **ECS** | **Eastern Cascades - South** |
| **KLW** | **Klamath-Siskiyou - West** |
| **KLE** | **Klamath-Siskiyou - East** |
| **ICC** | **Interior California Coast** |



## Habitat Modeling Process

Because spotted owl habitat use is influenced by factors occurring at different spatial scales, we developed habitat suitability models in two stages. In the first stage we used information from our literature review and experts to develop a series of alternative models of forest conditions corresponding to nesting-roosting habitat and foraging habitat within each modeling region. We used statistical modeling to test the effectiveness of these models and identify the forest structural models that best predicted the relative likelihood of a spotted owl territory being present. Spotted owl habitat is often subdivided into distinct components including: nesting habitat, roosting habitat, foraging habitat, and dispersal habitat. Habitats used for nesting and roosting are very similar, and so we combined them into nesting-roosting. Such areas are used for nesting, roosting, foraging, and dispersal by spotted owls, and are usually forests with more late-seral forest characteristics than "foraging" or "dispersal" habitat. Foraging habitat is thought to be largely used for foraging and other nocturnal activities, but also for dispersal (USFWS 1992; see Figure C3). Dispersal habitat is thought to largely have value for dispersal, to lack nest/roost sites and to provide few foraging opportunities. These categories are not absolutes, but instead represent generalizations (*e.g.*, one should not infer that spotted owls never roost in "foraging" habitat). That said, it is important to understand that

**Figure C-3**. Venn diagram of relationships among spotted owl nesting-roosting, foraging, and dispersal habitats.




nesting-roosting habitat is generally considered to provide all or most habitat requirements, whereas foraging and dispersal habitats are considered to provide only a subset of the spotted owl's habitat requirements. For this effort, we attempted to accurately model the suitability of breeding habitat for spotted owls. Thus, we evaluated and modeled nesting-roosting and foraging habitat, but not dispersal habitat. While we recognized that dispersal plays an important

role in population performance, we elected not to formally model dispersal habitat. This is because relatively little is known about habitat selection during dispersal and, more importantly, the likely influences of habitat conditions on dispersal success. The influence of habitat on dispersal and population performance is treated within the HexSim portion of the modeling framework (see Overview of HexSim Spotted Owl Scenario, page C-56).

**Spatial scale for developing and evaluating models:**

To determine the spatial scale at which to develop habitat models, the modeling team sought a uniform analysis area size that generally corresponded to large differences between use and availability. Spotted owls have been found to respond to habitats at a variety of spatial scales (Solis and Gutiérrez 1990, Meyer *et al.* 1998, Franklin *et al*. 2000, Swindle *et al.* 1999, Thome *et al*. 1999, Zabel *et al.* 2003). Spotted owls do not build their own nests, but primarily utilize broken-top snags, tree cavities, dwarf mistletoe witch's brooms, or nests made by other species (Gutiérrez *et al.* 1995). Spotted owl habitat selection in the immediate vicinity of the nest (tens of meters around the nest tree) has been found to be strongly non-random, and largely associated with late-seral forest characteristics (Solis and Gutiérrez 1990, Meyer *et al.* 1998, Swindle *et al.* 1999). Areas at this small spatial scale are necessary, but often not sufficient to be selected by spotted owls because areas at larger spatial scales around the nest-site must contain attributes that also contribute to their survival and reproductive success (*e.g.*, Franklin *et al*. 2000, Olson *et al.* 2004, Dugger *et al.* 2005).

Ripple *et al.* (1991), Carey *et al.* (1992), Hunter *et al.* (1995), Thome *et al.* (1999), Meyer *et al*. (1998), and Zabel *et al.* (2003) all evaluated spotted owl habitat selection at a variety of spatial scales beyond the nest site itself. Spatial scales evaluated in these studies were based on the distribution of radio telemetry locations, presumed territorial behavior (nearest-neighbor distances), or various 'nested rings'. All studies found differences between spotted owl-centered (nest or activity center) locations and random or unoccupied locations across the range of spatial scales examined. However, the largest differences were often found in areas approximately the size of what Bingham and Noon (1997) defined as "core areas" (areas of the home range that received disproportionately more use than would be expected). An area of 158 to 200-ha has been used to describe/define spotted owl 'territory core areas', in western Oregon and the Klamath region (Hunter *et al.* 1995, Meyer *et al.* 1998, Franklin *et al*. 2000, Zabel *et al*. 2003, Olson *et al.* 2004, and Dugger *et al.* 2005). In northwestern Oregon, Glenn *et al.* (2005) found mean cumulative core areas to be 94 ha (SE = 14.9; n = 24). For the northern portion of the range we found little information directly comparable to the abovementioned studies, but estimated home range and core areas sizes and nearest-neighbor distances are larger in the extreme northern portion of the spotted owl's range (Forsman *et al*. 2005, Hamer *et al.* 2007, Davis and Dugger in press). Based on this review, we felt a 200-ha analysis area represented an area that is disproportionately used (more than expected) surrounding nest sites. We deal explicitly with geographic variation in home range size in HexSim (see below).

### Data Used for Model Development and Testing

### Vegetation data – the GNN-LT Database:

To develop rangewide models of relative habitat suitability for spotted owls, we required maps of forest composition and structure of sufficient accuracy to allow discrimination of attributes used for nesting, roosting and foraging by spotted owls. Past efforts to model, map and quantify habitat selection by spotted owls at regional scales have often suffered from lack of important vegetation variables, inadequate spatial coverage, and/or coarse resolution of available vegetation databases (Davis and Lint 2005). However, recent development of vegetation mapping products for the NWFP's Effectiveness Monitoring program (Hemstrom *et al*. 1998, Lint *et al.* 1999) provided detailed maps of forest composition and structural attributes for all lands within the NWFP area (coextensive with the range of the spotted owl). These maps were developed using Gradient Nearest Neighbor (GNN) imputation (Ohmann and Gregory 2002) and LandTrendr algorithms (Kennedy *et al.* 2007, 2010) and were available for two "bookend" dates (1996 and 2006 in Oregon and Washington, 1994 and 2007 in California).

The GNN approach is a method for predictive vegetation mapping that uses direct gradient analysis and nearest-neighbor imputation to ascribe detailed attributes of vegetation to each pixel in a digital landscape map (Ohmann and Gregory 2002). Forest attributes from inventory plots (Forest Inventory and Analysis, Current Vegetation Surveys, etc.) are imputed to map pixels based on modeled relationships between plots and predictor variables from Landsat thematic mapper imagery, climatic variables, topographic variables, and soil parent materials. The assumption behind GNN methods is that two locations with similar combined spatial "signatures" should also have similar forest structure and composition. The GNN models were developed for habitat modeling regions used for the NWFP northern spotted owl effectiveness monitoring modeling (Davis and Dugger in press). For the NWFP Effectiveness Monitoring program, GNN maps were created for the two bookend time periods mentioned above to 'frame' their analysis period for habitat status and trends. This novel bookend mapping approach presents challenges associated with spectral differences due to different satellite image dates, which might produce false vegetation changes. To minimize the potential for this, the bookend models were based on Landsat imagery that was geometrically rectified and radiometrically normalized using the LandTrendr process (Kennedy *et al.* 2007, 2010).

The large list of forest species composition and structure variables provided by GNN vegetation maps constitute an improvement in vegetation data for modeling and evaluating spotted owl habitat. For our modeling, we selected from a set of 163 variables, including basal area and tree density by size class and species, canopy cover of conifers and/or hardwoods, stand height, age, mean diameter and quadratic mean diameter by dominance class, stand density index, and measures of snags and coarse woody debris. Additional variables pertaining

to stand structural diversity and variability proved particularly useful for modeling spotted owl habitat.

The reliability or accuracy of vegetation databases poses a primary concern for wildlife habitat evaluation and modeling. The GNN maps come with a large suite of diagnostics detailing map quality and accuracy; these are contained in model region-specific accuracy assessment reports available at the LEMMA website (http://www.fsl.orst.edu/lemma/). For developing *a priori* models of spotted owl nesting/roosting habitat and foraging habitat, we generally selected GNN structural variables with plot correlation coefficients > 0.5 for an individual modeling region (42% were >0.7). On a few occasions when expert opinion or research results suggested a particular variable might be important, we used variables with plot correlations from 0.31 to 0.5 (Table C-1). For species composition variables, we attempted to use only variables with Kappas > 0.3. However, because we combined species variables into groups that expert opinion and research results suggested may represent influential community types, we occasionally accepted variables with Kappas > 0.2 and < 0.3 for individual variables within a group (Table C-2).

The GNN vegetation database was specifically developed for mid- to large-scale spatial analysis (Ohmann and Gregory 2002), suggesting that accuracies at the 30-m pixel scale may be less influential to results obtained at larger scales. Because we were interested in the utility of GNN at our analysis area (200 ha) spatial scale, we conducted less formal assessments where we compared the distribution of GNN variable values at a large sample of actual locations (known spotted owl nest sites and foraging sites) to published estimates of those variables at the same scale. In addition, we received comparisons of GNN maps to a number of local plot-based vegetation maps prepared by various field personnel. Based on these informal evaluations, we determined that GNN represents a dramatic improvement over past vegetation databases used for modeling and evaluating spotted owl habitat, and used the GNN-LandTrendr maps as the vegetation data for our habitat modeling.

**Table C-1**. Pearson correlation coefficients for GNN structural variables used in modeling relative habitat suitability models for spotted owls.

| Variable | Modeling region | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ECN | ECS | ICC | KLE | KLW | NCO | ORC | RDC | WCC | WCN | WCS | AVG | STD |
| **BAA_75_100** | | | 0.42 | | | | | | | | | 0.49 | 0.09 |
| **BAA_GE_100** | | | 0.37 | | | | | | | | | 0.46 | 0.12 |
| **BAA_GE_3** | 0.75 | | | | | 0.71 | | | 0.71 | 0.71 | | 0.70 | 0.06 |
| **BAC_50_75** | | | | | | | | 0.46 | | | | 0.45 | 0.06 |
| **BAC_75_100** | | | | | | | | 0.31 | | | | 0.50 | 0.09 |
| **BAC_GE_100** | | | | | | | | 0.57 | | | | 0.47 | 0.12 |
| **BAC_GE_3** | | | | | 0.65 | | | | | | | 0.73 | 0.06 |
| **BAH_3_25** | | | 0.50 | | | | | | | | | 0.50 | 0.07 |
| **BAH_PROP** | | | | | 0.67 | | | | | | | 0.66 | 0.03 |
| **CANCOV** | 0.76 | 0.80 | 0.71 | 0.71 | 0.71 | | | 0.70 | 0.74 | 0.74 | 0.80 | 0.74 | 0.04 |
| **CANCOV_CON** | | | | 0.67 | | | 0.73 | | | | | 0.74 | 0.07 |
| **DDI** | 0.65 | 0.73 | 0.65 | 0.65 | 0.65 | 0.77 | 0.74 | | 0.77 | 0.77 | 0.73 | 0.69 | 0.08 |
| **QMDC_DOM** | 0.44 | 0.64 | 0.52 | 0.52 | 0.52 | | | | | | 0.64 | 0.59 | 0.11 |
| **TPH_50_75** | | | | 0.35 | | | 0.52 | | 0.44 | 0.44 | | 0.42 | 0.06 |
| **TPH_75_100** | | 0.52 | | 0.41 | | 0.56 | 0.58 | | 0.56 | 0.56 | 0.52 | 0.48 | 0.09 |
| **TPH_GE_100** | | 0.48 | | 0.45 | | 0.57 | 0.63 | | 0.57 | 0.57 | 0.48 | 0.49 | 0.10 |
| **TPHC_GE_100** | | | | | | | | | 0.57 | 0.57 | | 0.50 | 0.10 |

**Table C-2**. Local scale accuracy assessments (kappa coefficients) for individual species variables within stand species composition variable groupings used in applicable modeling regions. N/A = variable not in best models for modeling region.

| | GNN DOM SPP | Common Name | East Cascades North | East Cascades South | Inner California Coast Ranges | Klamath East | Klamath West | North Coast Olympics | Oregon Coast | Redwood Coast | West Cascades Central | West Cascades North | West Cascades South | Average Kappa |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Evergreen hardwoods** | ARME | Pacific madrone | n/a | n/a | 0.43 | n/a | 0.43 | n/a | 0.49 | n/a | n/a | n/a | n/a | 0.45 |
| | LIDE3 | tanoak | n/a | n/a | 0.58 | n/a | 0.58 | n/a | 0.72 | n/a | n/a | n/a | n/a | 0.63 |
| | QUCH2 | canyon live oak | n/a | n/a | 0.35 | n/a | 0.35 | n/a | 0.46 | n/a | n/a | n/a | n/a | 0.39 |
| | UMCA | California laurel | n/a | n/a | 0.29 | n/a | 0.29 | n/a | 0.43 | n/a | n/a | n/a | n/a | 0.34 |
| **Northern Hardwoods** | ACMA3 | bigleaf maple | n/a | n/a | n/a | n/a | n/a | 0.41 | 0.30 | n/a | 0.41 | 0.41 | n/a | 0.38 |
| | ALRU2 | red alder | n/a | n/a | n/a | n/a | n/a | 0.44 | 0.33 | n/a | 0.44 | 0.44 | n/a | 0.41 |
| **Oak woodlands** | QUDO | blue oak | n/a | n/a | 0.68 | 0.68 | 0.68 | n/a | n/a | 0.41 | n/a | n/a | n/a | 0.62 |
| | QUGA4 | Oregon white oak | n/a | n/a | 0.35 | 0.35 | 0.35 | n/a | n/a | 0.34 | n/a | n/a | 0.52 | 0.38 |
| **Pines** | PICO | lodgepole pine | 0.26 | 0.57 | 0.28 | 0.28 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 0.35 |
| | PIJE | Jeffrey pine | n/a | 0.27 | 0.28 | 0.28 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 0.28 |
| | PIMU | Bishop pine | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | |
| | PIPO | ponderosa pine | 0.62 | 0.58 | 0.34 | 0.34 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 0.47 |
| **Douglas-fir** | PSME | Douglas-fir | 0.47 | 0.65 | n/a | 0.31 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 0.48 |
| **Subalpine** | ABAM | Pacific silver fir | 0.66 | 0.59 | n/a | n/a | n/a | 0.53 | n/a | n/a | 0.53 | 0.53 | 0.59 | 0.57 |
| | ABLA | subalpine fir | 0.58 | 0.39 | n/a | n/a | n/a | 0.48 | n/a | n/a | 0.48 | 0.48 | 0.39 | 0.47 |
| | ABMA | California red fir | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | |
| | ABPR | noble fir | 0.29 | n/a | n/a | n/a | n/a | 0.32 | n/a | n/a | 0.32 | 0.32 | n/a | 0.31 |
| | ABSH | Shasta red fir | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | |
| | CHNO | Alaska cedar | 0.29 | 0.19 | n/a | n/a | n/a | 0.28 | n/a | n/a | 0.28 | 0.28 | 0.19 | 0.25 |
| **Redwood** | SESE3 | redwood | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 0.59 | n/a | n/a | n/a | 0.59 |

**Spotted owl location data:**

Spotted owl data used in model development consisted of site center locations documented within three years (plus or minus) of the date of the GNN vegetation data. Site centers are the location of spotted owl nests or daytime roosts containing paired spotted owls. Site center data for the habitat suitability modeling was made available through the cooperation of a variety of sources throughout the spotted owl's range. Data come from long-term demographic studies as well as locations from other research projects, public, private, and tribal sources.

Substantial effort was expended on verification of both the spatial accuracy and territory status of each site center in the data set. We specifically requested and received very high-quality data from spotted owl demography study areas (DSAs). For areas outside of DSAs, we obtained a large set of additional locations from NWFP Effectiveness Monitoring program (Davis and Dugger in press); the majority of these site centers had been evaluated for spatial accuracy. We also obtained and verified data sets from private timber companies, USFS Region 5 NRIS database and a number of research and monitoring projects across the species' range.

Because of the spatial extent of our analysis area (>23 million ha), we do not have the luxury of having equal survey effort throughout the region. Instead we have data from research studies, monitoring of demographic rates, management efforts, and other sources. While spotted owl demographic study areas have been intensively and extensively studied for long periods of time (see Anthony *et al.* 2006 and Forsman *et al.* 2011) and provide the highest- quality data sets, they comprise ~12% of the spotted owl's geographic range (based on our masked modeling regions). As importantly, for some modeling regions the proportion of total area and/or spotted owl locations within DSAs is very low. Given the DSAs represent nearly the only areas within the spotted owl's range that have consistently been surveyed over long periods of time and that they represent a smaller portion of the species' geographic range, the data from them (at the scale of a modeling region) is generally spatially aggregated. Spotted owl site location data from the DSAs represent a much smaller portion of the spotted owl's range than the full data set we used (Table C-3), and the larger data set represents more fully the spectrum or gradient of biotic and abiotic features that spotted owls select for nesting and roosting. For example, the total number of spotted owl site locations inside DSAs was 1,199, and when thinned by 3 km was 755. In contrast, the total number of site locations outside of DSAs was 2,591, and when thinned was 2,110. With our 200-ha analysis area, if we would have sampled from only the DSAs we would have sampled ~151,000 ha around thinned DSA sites versus the 573,000 ha sampled around all thinned sites.

**Table C-3**. Comparison of area and spotted owl location data within modeling regions and demographic study areas (DSAs).

| Modeling Region | Acronym | Percentage of Region in DSA | Number of NSO Sites in DSA | Number of NSO Sites Outside DSA |
|---|---|---|---|---|
| ALL MODELING REGIONS | ALL | 12.34% | 1199 | 2591 |
| North Coast Olympics | NCO | 7.29% | 166 | 79 |
| Oregon Coast | ORC | 30.88% | 352 | 102 |
| East Cascades South | ECS | 20.49% | 78 | 45 |
| East Cascades North | ECN | 23.45% | 132 | 84 |
| West Cascades North | WCN | 0.92% | 3 | 77 |
| West Cascades Central | WCC | 19.21% | 57 | 157 |
| West Cascades South | WCS | 6.58% | 57 | 435 |
| Klamath East | KLE | 10.31% | 98 | 374 |
| Klamath West | KLW | 15.24% | 127 | 335 |
| Inner California Coast Ranges | ICC | 0.75% | 8 | 300 |
| Redwood Coast | RDC | 10.23% | 121 | 603 |

Outside of DSAs, the quantity and density of site center data varies widely. While we have attempted to compile a large sample of site centers that is broadly representative of the entire distribution of spotted owls, the overall distribution of sample sites is somewhat clumped. Areas with few nest locations are a result of: 1) few surveys being conducted, 2) the absence of spotted owls, or 3) data being unavailable. We did not want the modeling results to be a function of the intensity of spotted owl sampling throughout the region, but to be as close of an approximation as possible of spotted owl-habitat relationships. Phillips *et al.* (2009) noted that spatially biased survey data present major challenges to distributional modeling by over-weighting areas where intensive sampling has occurred. Therefore, within each modeling region we “thinned” the spotted owl nest locations such that the minimum distance between nest locations would be 3.0 km (thinning with a 3 km distance resulted in removing ~25% of the locations available to us). Carroll *et al.* (2010) used a similar approach in their modeling of other species whereby clusters of records were identified and one record from the cluster was randomly selected from the set. Using a 3 km thinning distance retained 75% of the total data, and did not have a large effect on those modeling regions with small initial sample sizes (<100) of site center locations (Table C4).

**Table C-4**. Sample size of spotted owl site center locations (1993-1999) by modeling region and the impact of various thinning distances (minimum allowable distance between site centers) on sample size.

| | | Thinning Distance | | | | | |
|---|---|---|---|---|---|---|---|
| **Modeling Region** | **Total Sites** | **1 km** | **1.5 km** | **2 km** | **2.5 km** | **3 km** | **4 KM** |
| **NCO** | 241 | 236 | 229 | 221 | 209 | 196 | 162 |
| **OCR** | 454 | 430 | 414 | 371 | 325 | 281 | 202 |
| **RDC** | 724 | 716 | 670 | 547 | 461 | 392 | 284 |
| **WCN** | 80 | 80 | 79 | 78 | 77 | 77 | 74 |
| **WCC** | 214 | 211 | 205 | 195 | 182 | 173 | 144 |
| **WCS** | 489 | 489 | 487 | 482 | 477 | 470 | 342 |
| **ECN** | 216 | 215 | 209 | 203 | 195 | 184 | 155 |
| **ECS** | 123 | 122 | 119 | 112 | 104 | 93 | 67 |
| **KLW** | 462 | 460 | 454 | 440 | 414 | 358 | 275 |
| **KLE** | 472 | 468 | 463 | 455 | 434 | 381 | 285 |
| **ICC** | 308 | 308 | 307 | 300 | 286 | 253 | 199 |
| **Total** | **3783** | **3735** | **3636** | **3404** | **3164** | **2858** | **2189** |
| **Percentage of total** | **100** | **98.7** | **96.1** | **90.0** | **83.6** | **75.5** | **57.9** |

Due to the increased influence of the barred owl on spotted owls, we followed, in part, the modeling approach used by Davis and Dugger (in press) to reduce the influence of barred owls on apparent habitat associations of spotted owls. For our effort, we wanted our models to identify areas with more or less nesting suitability for spotted owls. Because barred owls have apparently displaced many spotted owls from previously-occupied nesting areas, sometimes into habitat types/conditions that spotted owls only rarely used prior to the barred owl's invasion (Gremel 2005, Gutiérrez *et al.* 2007), we did not want to evaluate their "displaced habitat use", but instead their use of habitat without the larger, current impact of barred owls. Although barred owls were known to be widely distributed in the northern portion of the spotted owl's range in 1996, Gremel (pers. comm. 2010) suggested barred owl densities were substantially lower in 1996 than in 2006. Pearson and Livezey (2003) reported that barred owls had increased by an average of 8.6% per year between 1982 and 2000 on parts of the Gifford Pinchot National Forest (GPNF), Washington. Subsequently, Livezey *et al.* (2007) reported that the 98 known barred owl sites on the GPNF in 2001 had increased to 143 sites in 2006. Thus, in an attempt to reduce the influence of barred owls on spotted owl habitat use, we developed and tested models using GNN vegetation data from 1996 (assumed to be the period with lower barred owl influence) along with spotted owl location information plus or minus three years from 1996. Those models were then projected to the most current (2006) GNN layer to predict contemporary relative habitat suitability (RHS). Each region's model was then tested by comparing with RHS values at independent

sites from the 2006 spotted owl locations (only those that did not overlap with the 1996 locations).

**Developing Habitat Definitions:**

**Nesting and roosting habitat**

Prior to developing models, we attempted to synthesize both the literature and information from experts. From the literature, we emphasized studies evaluating habitat selection over those that described habitat features (associations) around spotted owl locations, but did not evaluate selection. This synthesis resulted in the development of a series of definitions of spotted owl nesting-roosting and foraging habitat. For example, several published studies concluded that nesting spotted owls strongly select for areas with canopy cover >70% and many large trees nearby and strongly select against areas with lower amounts of canopy cover and few or no large trees nearby. We therefore created definition "$NR_1$" (nesting-roosting definition number 1) based on canopy cover and density of large trees (*e.g.*, trees >75 cm dbh). Because experts and/or other published studies typically supported several (i) alternative NR definitions, we created roughly ten alternative NR habitat definitions ($NR_2$, $NR_3$, $NR_i$, etc.) per modeling region. We used an identical process to develop a series of foraging (F) habitat definitions for each modeling region (Tables C5 and C6 provide an example of this process). It is important to recognize that these habitat definitions are binary for each pixel; either the pixel contained each of the features in the definition (and was therefore considered habitat), or it did not (it was considered non-habitat).

**Table C-5**. Spotted owl nesting-roosting habitat variables for the northern Coast Ranges and Olympic Peninsula.

| Habitat characteristics from expert panel, literature | GNN Variable expression |
|---|---|
| Canopy cover of conifers is ≥ than 80% | CANCOV_CON_GE_80 |
| Mean stand diameter is ≥ than 50cm | MNDBHBA_CON_GE_50 |
| Structure should include ≥ 70 medium trees/ha | TPH_GE_50_GE_70 |
| Structure should include ≥ 20 larger trees/ha | TPH_GE_75_GE_20 |
| Very large remnant trees are important (≥5/ha) | TPH_GE_100_GE_5 |
| Canopy layering/diversity is important | DDI_GE_6 * |

*DDI = Diameter Diversity Index (ranges from 1-10)

**Table C-6**. Sample definitions of spotted owl nesting-roosting habitat based on variables and values from Table 5.

| | **Candidate nesting/roosting habitat definitions** |
|---|---|
| $NR_1$ | CANCOV_CON_GE_80 + MNDBHBA_CON_GE_50 + DDI_GE6 |
| $NR_2$ | CANCOV_CON_GE_80 + MNDBHBA_CON_GE_50 + TPH_GE_75_GE_20 + TPH_GE_100_GE_5 + DDI_GE_6 |
| $NR_3$ | CANCOV_CON_GE_80 + TPH_GE_50_GE_70 + TPH_GE_75_GE_20 + TPH_GE_100_GE_5 + DDI_GE_6 |
| $NR_4$ | CANCOV_CON_GE_70 + MNDBHBA_CON_GE_50 + TPH_GE_75_GE_20 + DDI_GE_5 |

## Foraging habitat

Foraging habitat definitions were informed by published and unpublished literature and input from experts. In this process, foraging habitat was, by definition, different than nesting-roosting habitat. This is not to suggest that spotted owls do not forage in nesting-roosting habitat, but for the sake of being explicit in this process, foraging habitat was distinct from nesting-roosting habitat. In general, foraging habitat definitions had lower thresholds of canopy cover, tree size, and canopy layering than nesting-roosting definitions (Tables C7 and C8 provide an example of this process).

**Table C-7**. Spotted owl foraging habitat variables for the northern Coast Ranges and Olympic Peninsula.

| **Habitat characteristics from expert panel, literature** | **GNN Variable expression** |
|---|---|
| Canopy cover of conifers is ≥ than 70% | CANCOV_CON_GE_70 |
| Mean stand diameter is ≥ than 40 cm | MNDBHBA_CON_GE_40 |
| Structure should include ≥ 50 medium trees/ha | TPH_GE_50_GE_50 |
| Structure should include ≥ 8 larger trees/ha | TPH_GE_75_GE_8 |
| Canopy layering/diversity is important | DDI_GE_4 * |

*DDI = Diameter Diversity Index (ranges from 1-10)

**Table C-8**. Sample definitions of spotted owl foraging habitat based on variables and values from Table C7.

| | **Candidate nesting/roosting habitat definitions** |
|---|---|
| $F_1$ | CANCOV_CON_GE_70 + MNDBHBA_CON_GE_40 + DDI_GE_4 |
| $F_2$ | CANCOV_CON_GE_70 + MNDBHBA_CON_GE_40 + TPH_GE_75_GE_8 + DDI_GE_6 |
| $F_3$ | CANCOV_CON_GE_70 + TPH_GE_50_GE_50 + TPH_GE_75_GE_8 + DDI_GE_4 |
| $F_4$ | CANCOV_CON_GE_60 + MNDBHBA_CON_GE_40 + TPH_GE_75_GE_8 + DDI_GE_4 |

Because attributes of habitat such as amount of edge and core area have been shown to influence both habitat selection and fitness (Franklin *et al.* 2000) of spotted owls, we also included NR "core" and "edge" metrics.

## Abiotic variables

Because published literature and information from experts suggested that abiotic features might be important in determining spotted owl habitat use and selection, we evaluated a series of abiotic features known or suspected to influence spotted owl habitat selection and use (Table C9). Numerous studies have shown that local geographic features such as slope position, aspect, distance to water, and elevation have been found to influence spotted owl site selection (Stalberg *et al.* 2009, Clark 2007). Several authors (Blakesley *et al.* 1992, Hershey *et al.* 1998, LaHaye and Gutiérrez 1999) have noted the absence of spotted owls above particular elevational limits (whether this limit is due to forest structure, prey, competitors, parasites, diseases, and/or extremes of temperature or precipitation is not known). At broader scales, temporal variation in climate has been shown to be related to fitness (Franklin *et al.* 2000, Olson *et al.* 2004, Dugger *et al.* 2005, Glenn *et al.* 2010), suggesting that spatial variation in climate may also influence habitat suitability for spotted owls. Ganey *et al.* (1993) found that Mexican spotted owls (*S. o. lucida*) have a narrow thermal neutral zone and others (*e.g.*, Franklin *et al*. 2000) have assumed the northern spotted owl to be similar in this regard. Furthermore, the spotted owl's selection for areas with older-forest characteristics has been hypothesized to, in part, be related to its needing cooler areas in summer to avoid heat stress (Barrows and Barrows 1978). Temperature extremes (winter low and summer high) as well as potential breeding-season specific stressors (spring low temperature and high spring precipitation) are also considered potentially useful predictor variables for our purposes (Carroll 2010, Glenn *et al.* 2010). By including climate variables as candidate variables in our habitat suitability modeling, we evaluated whether climate effects on spotted owl fitness are translated into patterns of the species' distribution.

**Developing models:**

MaxEnt compares the characteristics (variables included in the models) of the training data sites to a random selection of ~10,000 random "background" (available) locations. We only used the linear, quadratic, and threshold features within MaxEnt (*i.e.,* hinge and product features were not used).

**We used the following model-building and evaluation process within each modeling region**

1) Each nesting-roosting habitat definition is a single-variable model. Thus, if we developed 10 nesting-roosting habitat definitions for a region, we compared 10 nesting-roosting habitat models for that region. We used MaxEnt to determine the best nesting-roosting habitat definition within each region (see model evaluation, below).

2) Within each modeling region that has foraging habitat definitions, we combined the best nesting-roosting habitat definition(s) with each foraging habitat definition to evaluate whether the addition of foraging habitat improved model performance. Models were considered to have been improved if the addition of foraging habitat increases the ranking of the model. If the addition of foraging habitat improved the model's performance, we used the nesting-roosting + foraging habitat model for step 3 (below). If not, we used the best nesting-roosting model(s) for step 3.

3) For abiotic variables, we developed univariate or multivariate models using the variables in Table C9. Carroll (2010) found that mean January precipitation, mean July precipitation, mean January temperature, and mean July temperature were the variables in the best, of 30, climate models he evaluated. He found the two precipitation metrics were the most influential of the four. Franklin *et al.* (2000) also found climate variables to influence spotted owl survival and reproduction. We included three climate models: 1) the four variables Carroll (2010) reported, 2) mean January precipitation and mean July precipitation, 3) mean January precipitation and mean January temperature. We "challenged" the best model(s) after step 2 by adding each abiotic model to it (*sensu* Dunk *et al.* 2004), in an attempt to improve its predictive ability. The abiotic models were not compared to each other, but were compared in order to see if their addition to the best biotic (nesting-roosting or nesting-roosting + foraging) model resulted in an improved model (see step 2). If the biotic plus abiotic model was an improvement over the biotic-only model, we used the combination model, otherwise we used the biotic-only model. The reason abiotic-only models were not evaluated is that it is illogical to suggest that spotted owls (a species that nests in trees) might only respond to abiotic factors when selecting nesting areas. In contrast, we could develop a logical biological argument that spotted owls might respond only to biotic features when selecting nesting areas. We could also develop logical biological arguments

articulating how a combination of biotic and abiotic factors might influence the selection of nesting areas.

**Model-building hierarchy**

The spatial distribution of spotted owl territories is influenced by a wide variety of environmental gradients operating at different spatial scales. At the smallest scale we evaluated, features such as the amount of nesting-roosting and/or foraging habitat within a core area, the amount of edge between spotted owl habitat and non-habitat, or amount of "core habitat" (*sensu* Franklin *et al*. 2000) have all be shown to influence spotted owl distribution, abundance, or fitness. Each of those variables, however, is a structural variable. That is, they are based on habitats comprised of various structural elements (*e.g.*, large trees, high canopy cover). However important and influential these variables are to spotted owls, other variables such as plant species composition (broadly speaking), topographic position, climate, and/or elevation are also likely to influence their distribution, abundance, and perhaps fitness (Franklin *et al.* 2000, Olson *et al*. 2004, Dugger *et al.* 2005, Glenn 2009).

In part, the partitioning of the spotted owl's geographic range into 11 modeling regions should act to reduce the influence of broad patterns in plant species composition, climate and/or elevation on the species. Nonetheless, we were interested in evaluating whether habitat suitability is influenced by local variation in these non-structural variables.

Stand structure and the spatial arrangement of forest patches have been found to influence spotted owl fitness (Franklin *et al*. 2000, Olson *et al*. 2004, Dugger *et al*. 2005). Edge between nesting-roosting habitat and other habitat types is thought to afford foraging spotted owl opportunities when habitats, but which are rarely used, are juxtaposed closely with habitats spotted owls use. "Core" habitat includes those areas of spotted owl nesting habitat not subjected to edge-effects. Franklin *et al*. (2000) estimated core habitat by buffering all spotted owl habitat (largely mature forest areas) by 100 m and estimating the size of the habitat excluding the 100 m buffer.

Spotted owl experts noted that mid-scale or landscape level patterns such as tree species composition and topography may also influence the local distribution and density of spotted owls. For example, within many of the modeling regions, there exists variation in tree species composition, but forests with different species compositions may still have similar structural attributes (*e.g.*, high canopy cover, multi-storied, large trees). Some forest types (regardless of their structural attributes) are rarely, if ever, used by spotted owls, so we attempted to account for this variation by evaluating models that include some compositional variables.

Many of our 11 modeling regions contain high-elevation areas above the elevational extremes normally used by spotted owls. In some higher elevation areas there exist structurally complex, multi-storied forests with large trees – areas with similar structural characteristics to those used by spotted owls.

However, spotted owls rarely if ever use such areas. Our intention was to attempt to account for this in our modeling.

We recognize the hierarchical nature of these environmental factors and their possible influence on spotted owl distribution. Our model building approach took this into consideration, by starting at the smallest scale and sequentially "challenging" models with variables from larger spatial scales. In order to focus on environmental features most directly linked to territory location, habitat selection, and individual fitness of spotted owls, we employed a bottom-up approach to building models (Table C9).

**Table C-9**. Categories of candidate variables, variable names, and order of the entry of variables into modeling process.

| Category | Variable | Order |
|---|---|---|
| Best climate/elevation model | Mean July Precipitation | |
| | Mean July Temperature | |
| | Mean July Precipitation | |
| | Mean July Temperature | |
| | Mean Elevation | |
| | | |
| Topographic position | Curvature | |
| | Insolation | |
| | Slope Position | |
| | | |
| Compositional variables (percent of basal area) | Redwood | |
| | Oak Woodland | |
| | Pine-dominated | |
| | Northern Deciduous Hardwoods | |
| | Evergreen Hardwoods | |
| | Douglas-fir | |
| | Subalpine forest | |
| | | |
| Habitat pattern | Core of NR habitat | |
| | Edge of NR habitat | |
| | | |
| Habitat structure | Foraging Habitat Amount | |
| | Nesting/Roosting Habitat | |

**Goals of MaxEnt Modeling:**

Our goals for the relative habitat suitability models were to find models that: 1) had good discriminatory ability, 2) were well calibrated, 3) were robust, and 4) had good generality. We sought models that were not over-fit, the consequences

of which would be to have models that fit the developmental data very closely, but which would not have worked well on data that were not used in their development. That is we sought models with good generality (*i.e.*, models that worked well in the modeling regions in general, not simply at classifying the developmental/training data). MaxEnt attempts to balance model fit and complexity through the use of regularization (see Elith *et al.* 2011). Elith *et al.* (2011) noted that MaxEnt fits a penalized maximum likelihood model, closely related to other penalties for complexity such as Akaike's Information Criterion (AIC, Akaike 1974). In order to evaluate whether any model region's model was over-fit we conducted rigorous cross-validation on each model (see below), and, when available we evaluated how well models classified independent data (see below).

**Model discrimination**

Once the best model was found for each region, we conducted a cross-validation of each model to evaluate how robust the model was. Each of 10 times we removed a random subset of 25% of the spotted owl locations, developed the model with the remaining 75% and classified using the withheld 25%. The area under the receiver operating characteristic curve (AUC) was evaluated for both training and test data within each region. AUC is a measure of a model's discrimination ability; in our case discrimination between spotted owl-presence locations and available locations (not discrimination of presence versus absence locations). AUC values, theoretically, range between 0 and 1.0, with values less than 0.5 having worse discriminatory ability than expected by chance, values closer to 0.5 suggesting no to poor discriminatory ability, and values closer to 1.0 suggesting excellent discriminatory ability.

For these analyses, AUC values essentially describe the proportion of times one could expect a random selection of an actual spotted owl nest site location to have a larger relative habitat suitability value than a random selection from available locations. It is therefore a threshold-independent measure of model discriminatory ability. Because our evaluation represents use versus availability and not use versus non-use, AUC values have an upper limit somewhat less than 1.0 (because some of the available locations are actually used by spotted owls). Even for good (well-discriminating) models, AUC values should be lower in areas where the background areas contain larger amounts of suitable habitat. Two contrasting examples are provided to make this point: 1) a model estimating a riparian-dependent bird species' distribution in the Great Basin may have a very high AUC value because there is large contrast between riparian vegetation where the bird nests and the vast majority of background locations in sage-steppe, vs. 2) a model estimating the distribution of a generalist omnivore (like a black-bear) in a national forest may have a lower AUC because so much of the background habitat is suitable for the species. The point is that AUC is a measure of discrimination, but that a use-versus-availability model's ability to discriminate is a function of both the animal's habitat specificity and the abundance of the animal's habitat in the region of interest. To evaluate the degree to which AUC values from each modeling region's MaxEnt model were

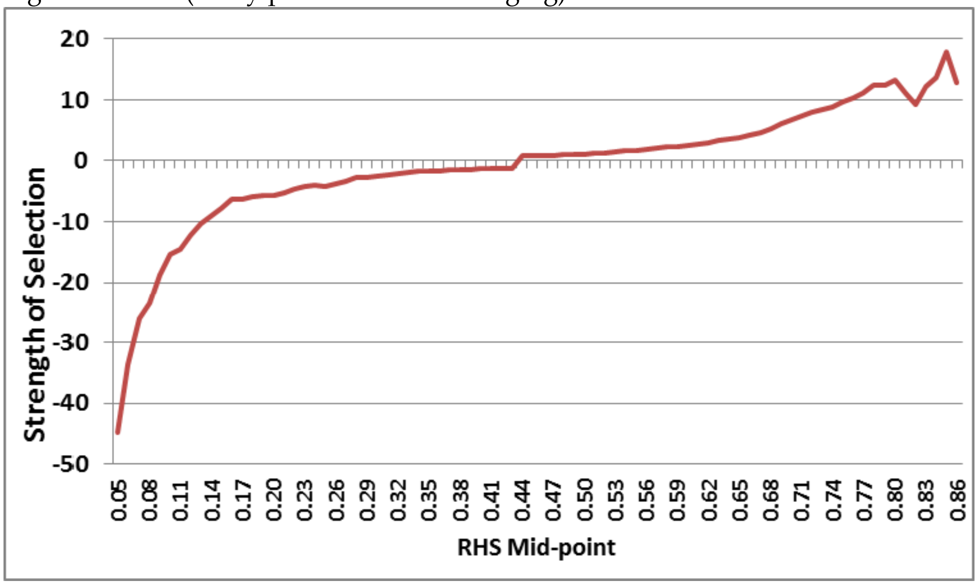
related to the abundance of suitable habitat we regressed AUC values against the proportion of each modeling region comprised of RHS values >30, >40, and >50 (the SOS values for all modeling regions showed selection for areas within this range – see Figure C-5 below). If the abundance of suitable habitat is high in areas with lower AUC values, and lower in areas with higher AUC values, the interpretation would be that the abundance of suitable habitat, not model discrimination ability, best explains this relationship.

In order to evaluate the degree to which AUC values were a function of the amount of suitable habitat in modeling regions, and thus help us interpret whether somewhat lower AUC values represented poor models versus a larger amount of suitable habitat in the modeling region, we evaluated the correlation between AUC values and the percentage of each modeling region with RHS scores above various thresholds corresponding to RHS values showing higher use than expected (see Model Calibration section below).

## Model Calibration

To assess model calibration we evaluated the agreement between RHS and observed proportions of sites occupied. Phillips and Elith (2010) noted that model discrimination and model calibration are independent measures. Model calibration refers to the agreement between predicted probabilities of occurrence (habitat suitability for our study) and observed proportions of sites occupied (Pearce and Ferrier 2000, Phillips and Elith 2010). Phillips and Elith (2010) note that model discrimination and model calibration are independent measures. Hirzel *et al.* (2006) (whose work Phillips and Elith [2010] expand upon), developed “strength of selection” metrics for species distribution models using a moving-window approach. Strength of selection (SOS) evaluations allow for an understanding of the use that areas with various habitat suitability values receive (by nesting spotted owls in our case) relative to the abundance of such areas in the study area (see Figure C4 below). Essentially, a well-calibrated model will show the species to use higher suitability areas disproportionately more and lower suitability areas disproportionately less. The shape of the relationship provides insights into the degree to which the species avoids or is attracted to areas with particular habitat suitability values.

**Figure C-4**. This *example* of the strength of selection (SOS) evaluation shows a well-calibrated model. Areas with a mid-point RHS (*i.e.*, relative habitat suitability value) of 0.05 (the moving window size here was 0.1) were used ~45-times *less* than would be expected based on its extent in the study area. Similarly, areas with a mid-point RHS of 0.8 (window of 0.75-0.85) were used ~12-times *more* than expected based on its extent in the study area. This figure was developed from a model trained on >3,000 spotted owl night locations (many presumed to be foraging).




**Habitat Modeling Results:**

The following section provides summary descriptions of the final "best" models for each modeling region; including information on the relative contribution of each covariate to the model, model evaluation metrics, and the results of validation against independent data sets conducted to date. Because the primary objective of this habitat modeling step was to provide accurate prediction of relative habitat suitability and subsequent likelihood of spotted owl occupancy, we focus on presenting evaluation of model performance, rather than description of spotted owl habitat associations. Tables and table series C10 to C17 provide descriptions of the best nesting-roosting habitat model, foraging habitat model, and full model for each modeling region, as well as model evaluation metrics (AUC and Gain) and the relative contribution of each variable to the full model (a heuristic estimate provided in the standard output from MaxEnt). AUC values were highly correlated with the percentage of each modeling region comprised of RHS values >30, >40, and >50 ($r^2$ = 0.9685, 0.9649, 0.9574, respectively). Hence, variation in AUC values among modeling regions (which ranged from 0.76 – 0.93) has less to do with model discrimination ability (*i.e.*, the quality of the model) and more to do with the quantity of suitably habitat in each modeling region.

See Table C18 for codes and descriptions of variables used in the models.

**Table Series C-10**. Highest-ranking (best) Nesting/Roosting habitat (NR), foraging habitat (F), and full models for coastal Washington, Oregon and California modeling regions.

**North Coast and Olympics Modeling Region (N= 196 training sites):**

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR06** | DDI (≥6) + TPH ≥ (>25/ha) + BAA GE3 (≥ 55 $m^2$/ha) | 0.8365 | 0.7667 |
| **F04** | MNDBHBA_CON (≥40); TPH_GE75 (≥10) | 0.8619 | 0.8817 |
| **Full Model** | NR06 + NR06EDGE + F04 + SLOPE POSITION+ ELEVATION + CURVATURE + SUBALPINE FOREST+JULY MAX TEMP+JANUARY PRECIP + JULY PRECP + INSOLATION + JANUARY MIN TEMP + NORTHERN HARDWOODS | 0.8989 | 1.057 |

**Oregon Coast Ranges Modeling Region (N = 281training sites)**

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR08** | CANCOV_CON (≥55) + DDI (≥6) + TPH_GE75 (≥20) | 0.7683 | 0.4498 |
| **F04** | DDI (≥4) + TPH_GE50 (≥30) | 0.7787 | 0.467 |
| **Full Model** | NR08 + NR08 EDGE + SLOPE POSITION + JULY MAX TEMP + JANUARY MIN TEMP + F04 + CURVATURE + INSOLATION + JULY PRECIP + JANUARY PRECIP + ELEVATION + NR08 CORE + NORTHERN HARDWOODS + EVERGREEN HARDWOODS | 0.864 | 0.811 |

**Redwood Coast Modeling Region (N = 389 training sites)**

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR03** | CANCOV (≥70) + MNDBHBA_CON (≥44) | 0.5928 | 0.0509 |
| **F05** | CANCOV (≥65) + BAC_GE50 (≥3) | 0.6256 | 0.0785 |
| **Full Model** | SLOPE POSITION + CURVATURE + NR03 EDGE + F05 + NR03 + REDWOOD + ELEVATION + JANUARY PRECIP + OAK WOODLAND + JULY MAX TEMP + INSOLATION + JANUARY MIN TEMP + NR03 CORE + JULY PRECIP | 0.760 | 0.335 |

**Table C-11**. Individual covariates and their contribution to full model.

| North Coast / Olympics | | Oregon Coast Ranges | | Redwood Coast | |
|---|---|---|---|---|---|
| **Full Model** | **%** | **Full Model** | **%** | **Full Model** | **%** |
| NR 06 | 42.4 | NR 08 | 29.4 | Slope Position | 48.2 |
| NR06Edge | 21.5 | NR08 Edge | 24.2 | Curvature | 11.2 |
| NR06+F04 | 20.1 | Slope position | 11.9 | NR03 Edge | 10.3 |
| Slope position | 6.0 | July Max Temp | 10.1 | NR03 + F05 | 6.1 |
| Elevation | 3.6 | Jan Min Temp | 8 | NR 03 | 5.7 |
| Curvature | 1.8 | NR08 + F04 | 5.5 | Redwood (%BA) | 4.8 |
| Subalpine | 1.1 | Curvature | 4.1 | Elevation | 4.1 |
| July Max Temp. | 0.9 | Insolation | 3.1 | January Precip | 3.2 |
| Jan Precip. | 0.9 | July Precip | 1.5 | Oak Woodland | 2.6 |
| July Precip. | 0.8 | Jan Precip | 1.3 | July Max Temp | 1.3 |
| Insolation | 0.6 | Elevation | 0.4 | Insolation | 0.9 |
| Jan Min Temp | 0.3 | NR08 Core | 0.2 | Jan Min Temp | 0.7 |
| Northern Hdwd | 0.1 | Northern Hdwd | 0.2 | NR03 Core | 0.7 |
| | | Evergreen Hdwd | 0.1 | July precip | 0.4 |

**Table Series C-12**. Nesting/Roosting habitat, foraging habitat, and full models for Western Cascades modeling regions.

**Western Cascades Modeling Region (Northern Section) (N = 76 training sites)**

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR05** | CANCOV (≥80) + MNDBHBA_CON (≥60) + TPHC_GE100 (≥7) | 0.8377 | 0.7555 |
| **F01** | CANCOV (≥70); DDI (≥5); TPH_GE50 (≥42); BAA_GE3 (≥40) | 0.8417 | 0.7698 |
| **Full Model** | NR05 EDGE + NR05 + SLOPE POSITION + CURVATURE + ELEVATION + JANUARY PRECIP + NORTHERN HARDWOODS + JULY MAX TEMP + SUBALPINE FOREST + INSOLATION + JULY PRECIP + F01 + JANUARY MIN TEMP + NR05 CORE | 0.931 | 1.393 |

**Western Cascades Modeling Region (Central Section) (N = 171 training sites)**

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR09** | TPH_GE50 (≥ 64) + TPH_GE75 (≥ 16) + TPHC_GE100 (≥ 4) | 0.7965 | 0.5825 |
| **F01** | CANCOV (≥70) + DDI (≥4) + TPH_GE50 (≥37) + BAA_GE3 (≥ 37) | 0.816 | 0.6575 |
| **Full Model** | NR09 EDGE + F01 + CURVATURE + ELEVATION + NORTHERN HARDWOODS + SUBALPINE + SLOPE POSITION + JANUARY MIN TEMP + NR09 + JULY PRECIP + JULY MAX TEMP + INSOLATION + NR09 CORE + JANUARY PRECIP | 0.892 | 1.024 |

**Western Cascades Modeling Region (Southern Section) (N = 470 training sites)**

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR02** | CANCOV (≥ 70) + MNDBHBA_CON (≥ 50) + TPH_GE75 (≥ 22) | **0.6877** | **0.2343** |
| **F01** | CANCOV (≥ 60) + DDI (≥ 4) + QMDC_DOM (≥ 37) | **0.6931** | **0.2385** |
| **Full Model** | NR02 + SLOPE POSITION + CURVATURE + F01 + JANUARY MIN TEMP + NORTHERN HARDWOODS + INSOLATION + JULY PRECIP + JANUARY PRECIP + JULY MAX TEMP + ELEVATION | **0.762** | **0.355** |

**Table C-13**. Individual covariates and their contribution to full model.

| **Western Cascades North** | | **Western Cascades Mid** | | **Western Cascades South** | |
|---|---|---|---|---|---|
| **Full Model** | **%** | **Full Model** | **%** | **Full Model** | **%** |
| NR05 Edge | 34.4 | NR09 Edge | 44.8 | NR 02 | 62.9 |
| NR 05 | 17.2 | NR09 + F01 | 13.9 | Slope Position | 17.8 |
| Slope Position | 13.0 | Curvature | 8.5 | Curvature | 4.7 |
| Curvature | 12.6 | Elevation | 7.6 | NR02 + F01 | 3.9 |
| Elevation | 8.0 | Northern Hdwd | 7.4 | Jan Min Temp | 3.9 |
| Jan Precip | 4.3 | Subalpine | 4.2 | Northern Hdwd | 1.9 |
| Northern Hdwd | 3.7 | Slope Position | 4.1 | Insolation | 1.5 |
| July Max Temp | 2.2 | Jan Min Temp | 2.4 | July Precip | 1.5 |
| Subalpine | 1.4 | NR 09 | 1.8 | January Precip | 0.9 |
| Insolation | 0.9 | July Precip | 1.5 | July Max Temp | 0.5 |
| July Precip | 0.9 | July Max Temp | 1.4 | Elevation | 0.5 |
| NR05 + F01 | 0.8 | Insolation | 1.0 | | |
| Jan Min Temp | 0.5 | NR09 Core | 0.7 | | |
| NR05 Core | 0.2 | Jan Precip | 0.7 | | |
| NR05 Edge | 34.4 | | | | |

**Table Series C-14**: Nesting/Roosting habitat, foraging habitat, and full models for Eastern Cascades modeling regions.

**Eastern Cascades Modeling Region (Northern Section) (n = 182 training sites)**

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR06** | CANCOV (≥ 70) + DDI (≥ 5) + MNDBHBA_CON (≥ 42) | 0.685 | 0.2263 |
| **F03** | CANCOV (≥52) + QMDC_DOM (≥30) + BAA_GE3 (≥23) | 0.7347 | 0.3114 |
| **Full Model** | NR06 + SLOPE POSITION + DOUGLAS-FIR + JANUARY MIN TEMP + ELEVATION + F03 + NR06 EDGE + JULY MAX TEMP + SUBALPINE FOREST + JANUARY PRECIP + CURVATURE + INSOLATION + JULY PRECIP + PINE | 0.879 | 0.843 |

**Eastern Cascades Modeling Region (Southern Section) (N = training sites)**

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR07** | CANCOV (≥ 70) + MNDBHBA_CON (≥ 45) + TPH_GE75 (≥ 9) | 0.7263 | 0.2912 |
| **F03** | MNDBHBA_CON(≥ 38) + DDI(≥ 4) + QMDC_DOM(≥ 32) | 0.7868 | 0.4797 |
| **Full Model** | (F03 + NR07) + NR07 + NR07 EDGE + PINE + DOUGLAS-FIR + JANUARY MIN TEMP + ELEVATION + SLOPE POSITION + NR07 CORE + JULY MAX TEMP + INSOLATION + JANUARY PRECIP + CURVATURE + SUBALPINE FOREST + JULY PRECIP | 0.889 | 0.957 |

**Table C-15**. Individual covariates and their contribution to full model.

| Eastern Cascades South | | Eastern Cascades North | |
|---|---|---|---|
| **Full Model** | **%** | **Full Model** | **%** |
| NR07 + F03 | 18.4 | NR06 | 20 |
| NR 07 | 13.9 | Slope Position | 14.6 |
| NR07 Edge | 11.7 | Douglas-fir | 13.6 |
| Pine | 10.7 | Jan Min Temp | 10.6 |
| Douglas-fir | 10.7 | Elevation | 8.3 |
| Jan Min Temp | 9.5 | NR06 + F03 | 6.8 |
| Elevation | 5.4 | NR06 Edge | 5.7 |
| Slope Position | 4.6 | July Max Temp | 4.1 |
| NR07 Core | 4.5 | Subalpine | 4.0 |
| July Max Temp | 3.3 | January Precip | 3.3 |
| Insolation | 3.2 | Curvature | 2.9 |
| January Precip | 1.6 | Insolation | 2.7 |
| Curvature | 1.5 | July Precip | 2.1 |
| Subalpine | 0.6 | Pine | 1.5 |
| July Precip | 0.4 | | |

**Table Series C-16**. Nesting/Roosting habitat, foraging habitat, and full models for Klamath-Siskiyou Mountains and Interior California modeling regions.

**Western Klamath Mountains (N = 357 training sites)**

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR01** | CANCOV (≥75) + DDI (≥6) + QMDC_DOM (≥50) | 0.6608 | 0.1677 |
| **F03** | DDI (≥4) + BAH_PROP (0.25 - 0.70) + BAC_GE3 (≥18) | 0.6751 | 0.1886 |
| **Full Model** | SLOPE POSITION + NR01 EDGE + NR01 + CURVATURE + JANUARY PRECIP + JULY PRECIP + NR01 CORE + JANUARY MIN TEMP + ELEVATION + INSOLATION + JULY MAX TEMP + F03 + OAK WOODLAND + EVERGREEN HARDWOODS | 0.769 | 0.396 |

**Eastern Klamath Mountains Modeling Region (N = 378 training sites)**

| **Model** | | **AUC** | **GAIN** |
|---|---|---|---|
| **NR01** | CANCOV (≥65) + DDI (≥5.5) + QMDC_DOM (≥42) | 0.7052 | 0.2601 |
| **F05** | CANCOV_CON (≥45) + TPH_GE50 (≥23) + QMDC_DOM (≥30) | 0.7075 | 0.2613 |
| **Full Model** | NR01 + SLOPE POSITION+ DOUGLAS-FIR+ ELEVATION + NR01 EDGE + INSOLATION + JAN PRECIP+ F05 + CURVATURE + JULY MAX TEMP+ JAN MIN TEMP+ NR01 CORE + OAK WOODLAND+ PINE + SUBALPINE | 0.830 | 0.605 |

**Interior California Coast Ranges (N = 251 training sites)**

| **Model** | | **AUC** | **GAIN** |
|---|---|---|---|
| **NR02** | CANCOV (≥65) + MNDBHBA_CON (≥46) + BAA_GE ≥75) | 0.7136 | 0.2975 |
| **F04** | DDI (≥3.5) + QMDC_DOM (≥30) + BAH_3_25 (≥5) | 0.7296 | 0.3286 |
| **Full Model** | NR02 + NR02 EDGE + SLOPE POSITION + JULY MAX TEMP + CURVATURE + F04 + NR02 CORE + JULY PRECIP + JAN PRECIP + INSOLATION + JAN MIN TEMP + EVERGRN HDWD + PINE +OAK WOODLAND + ELEVATION | 0.820 | 0.540 |

**Table C-17**. Individual covariates and their contribution to full model.

| **Western Klamath** | | **Eastern Klamath** | | **Interior CA Coast Ranges** | |
|---|---|---|---|---|---|
| **Full Model** | % | **Full Model** | % | **Full Model** | % |
| Slope Position | 33.0 | NR01 | 28.3 | NR02 | 29.9 |
| NR01 Edge | 32.2 | Slope Position | 24.6 | NR02 Edge | 19.8 |
| NR01 | 10.9 | Douglas-fir | 12.1 | Slope Position | 12.4 |
| Curvature | 6.6 | Elevation | 9.2 | July Max Temp | 11.1 |
| January Precip | 6.1 | NR01 Edge | 6.8 | Curvature | 5.6 |
| July Precip | 4.4 | Insolation | 5.4 | NR02 + F04 | 4.9 |
| NR01 Core | 1.6 | Jan Precip | 4.9 | NR02 Core | 3.3 |
| Jan Min Temp | 1.3 | NR01 + F05 | 3.3 | July Precip | 2.6 |
| Elevation | 1.1 | Curvature | 2.2 | Jan. Precip | 2.4 |
| Insolation | 1.0 | July Max Temp | 1.2 | Insolation | 2.0 |
| July Max Temp | 0.8 | Jan Min Temp | 0.8 | Jan. Min Temp | 1.8 |
| NR01 + F03 | 0.5 | NR01 Core | 0.5 | Evergrn Hdwd | 1.7 |
| Oak Woodland | 0.2 | Oak Woodland | 0.2 | Pine | 1.3 |
| Evergrn Hrdwd | 0.2 | Pine | 0.2 | Oak Woodland | 0.7 |
| | | Subalpine | 0.1 | Elevation | 0.5 |

**Table C-18**. Codes and descriptions of stand structural variables from GNN and compositional variables used in relative habitat suitability models.

| Variable | Definition |
|---|---|
| CANCOV | Canopy cover of all live trees |
| CANCOV_CON | Canopy cover of all conifers |
| DDI | Diameter diversity index (structural diversity within a stand, based on tree densities within different DBH classes) |
| SDDBH | Standard deviation of DBH of all live trees |
| MNDBHBA_CON | Basal area weighted mean diameter of all live conifers |
| TPH_GE_50 | Live trees per hectare greater than or equal to 50 cm DBH |
| TPHC_GE_50 | Conifers per hectare greater than or equal to 50 cm DBH |
| TPH_GE_75 | Live trees per hectare greater than or equal to 75 cm DBH |
| TPHC_GE_75 | Conifers per hectare greater than or equal to 75 cm DBH |
| TPHC_GE_100 | Conifers per hectare greater than or equal to 100 cm DBH |
| QMDC_DOM | Quadratic mean diameter of all dominant and co-dominant conifers |
| BAA_GE_3 | Basal area of all live trees greater than or equal to 2.5 cm DBH |
| BAA_3_25 | Basal area of all live trees 2.5 to 25 cm DBH |
| BAA_GE_75 | Basal area of all live trees greater than or equal to 75 cm DBH |
| BAC_GE_3 | Basal area of conifers greater than or equal to 2.5 cm DBH |
| BAC_GE_50 | Basal area of conifers greater than or equal to 50 cm DBH |
| BAH_PROP | Proportion of BAA_GE_3 that is hardwood |
| BAH_3_25 | Basal area of all live hardwoods 2.5 to 25 cm DBH |
| **Compositional Variables** | |
| Evergreen Hardwoods | Basal area of tanoak, canyon, coast and interior live oaks, giant chinquapin, California bay and Pacific madrone |
| Subalpine | Basal area of silver fir, mountain hemlock, subalpine fir, red fir, Englemann spruce, |
| Pine | Basal area of ponderosa pine, Jeffrey pine, lodgepole pine, and Bishop pine |
| Northern Hardwoods | Basal area of red alder and bigleaf maple |
| Oak Woodland | Oregon white oak and blue oak |

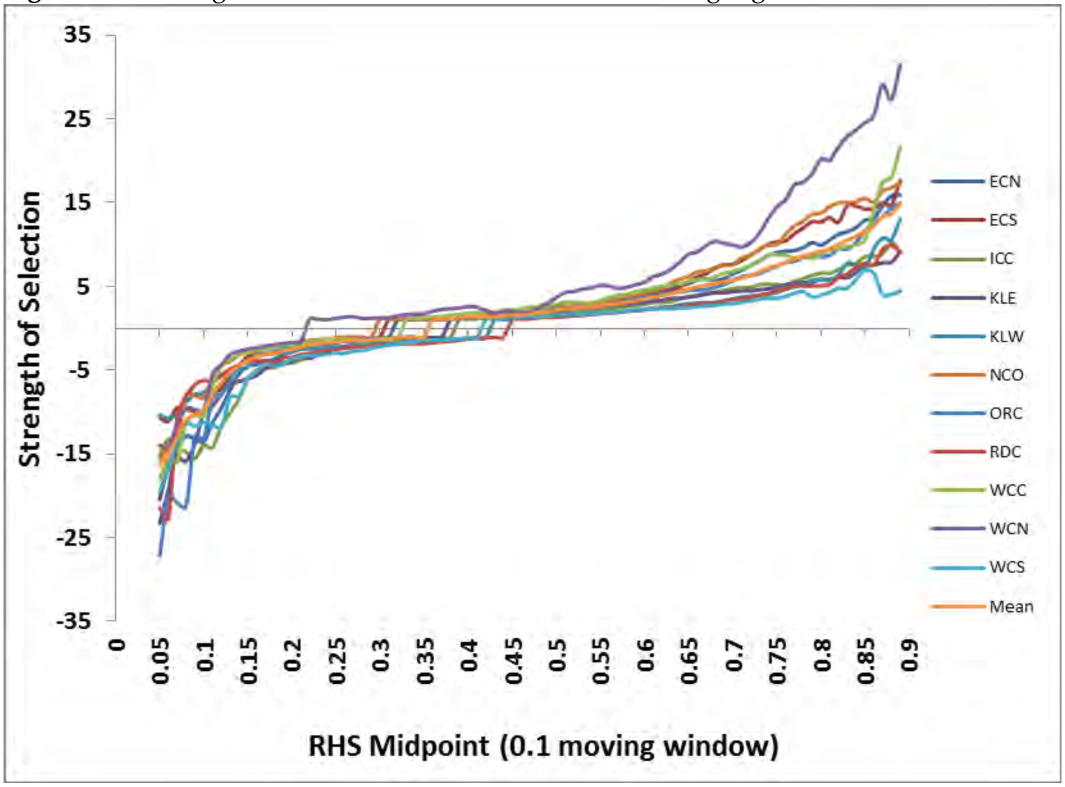
**Results of Model Evaluation and Testing:**

**Strength of selection results**

We plotted the observed use that areas with various RHS values receive (by nesting spotted owls in our case) relative to the abundance of such areas in each modeling region. Figure C5 shows the SOS curves for all 11 modeling regions. Although the degree of calibration varies among modeling regions, the RHS

models are generally well-calibrated, with strong selection for areas of RHS > 0.6 to 0.7, and avoidance of RHS <0.15 to 0.25.

**Figure C-5**. Strength of Selection evaluation for all modeling regions.




**<u>Results of Model Cross-Validation</u>**

Overall, each modeling region's model proved to be fairly robust, and thus gave us confidence in the model's generality. When we evaluated the differences in the percentages of spotted owl sites classified among 10 equally-sized RHS bins between the full model (using all of the spotted owl locations – thinned by 3 km) and the cross-validated (CV) models (*i.e.*, the 25% of observations that were withheld from the developmental model, each of 10-times for each modeling region) there were generally very small differences (Table C19). The maximum percentage point difference (percentage of observations from the full model minus percentage of observations CV model) was 11.1 (see Table C19). The mean difference of the absolute values among modeling regions ranged from 1.6 (for the Klamath West) to 4.5 (for the West Cascades North). Absolute values were used for calculating means because without doing so, the positive and negative values within a modeling region will always have a mean of 0, and thus don't accurately represent overall differences between full and cross-validated models. There was an inverse (negative logarithmic) relationship between sample size of spotted owl sites and mean difference in absolute value ($r^2 = 0.537$, $P = 0.01$). Nonetheless, the magnitude of differences was generally quite low. For example, 39% of the differences were <2.0, 81% of the differences were <5.0,

and only 7% of the differences were >7.0 (absolute value in each case). These findings suggest that none of the modeling region's full models were over-fit, and that all full models have good generality.

**Table C-19**. Results from cross-validation tests, showing absolute values of differences (% classified by full model - % classified in cross-validated model) among modeling regions.

| | **Absolute value of differences** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Po Bin** | **ECN** | **ECS** | **ICC** | **KLE** | **KLW** | **NCO** | **ORC** | **RDC** | **WCC** | **WCN** | **WCS** |
| **0-0.099** | 5.2 | 4.8 | 3.9 | 3.0 | 0.9 | 5.2 | 3.3 | 1.9 | 7.9 | 11.1 | 1.7 |
| **0.1-0.199** | 4.4 | 4.6 | 6.1 | 1.1 | 5.0 | 0.2 | 3.3 | 3.1 | 1.9 | 4.2 | 1.7 |
| **0.2-0.299** | 3.3 | 1.0 | 3.1 | 4.6 | 1.4 | 1.1 | 0.2 | 1.4 | 4.0 | 3.4 | 2.6 |
| **0.3-0.399** | 2.8 | 4.5 | 0.9 | 3.7 | 2.8 | 0.5 | 3.0 | 3.5 | 0.9 | 1.3 | 2.6 |
| **0.4-0.499** | 2.8 | 7.9 | 2.5 | 2.4 | 0.0 | 4.5 | 0.7 | 5.2 | 3.7 | 1.3 | 0.8 |
| **0.5-0.599** | 3.1 | 1.0 | 3.6 | 4.4 | 0.8 | 0.1 | 6.2 | 6.1 | 4.4 | 4.5 | 5.5 |
| **0.6-0.699** | 5.2 | 3.1 | 7.0 | 7.3 | 0.3 | 1.4 | 1.9 | 3.3 | 9.9 | 5.3 | 8.1 |
| **0.7-0.799** | 3.5 | 9.7 | 3.4 | 0.6 | 4.0 | 10.2 | 3.4 | 6.8 | 1.7 | 5.8 | 2.9 |
| **0.8-0.899** | 1.5 | 2.5 | 2.1 | 1.0 | 1.1 | 0.2 | 2.0 | 2.2 | 4.0 | 6.8 | 1.2 |
| **0.9-1.0** | 0.3 | 2.4 | 0.4 | 0.3 | 0.1 | 0.8 | 0.4 | 0.5 | 1.0 | 1.1 | 0.1 |
| **Mean** | **3.2** | **4.1** | **3.3** | **2.8** | **1.6** | **2.4** | **2.4** | **3.4** | **3.9** | **4.5** | **2.7** |

## Results of comparisons with independent data sets

To further evaluate the reliability of the models' predictions, we obtained independent (*i.e.* not used in model development) samples of spotted owl territory locations that represented the period 1993 to 1999 (Test96) and 2003 to 2009 (Test06) and compared their associated RHS values to corresponding values for spotted owl sites used in model development. All test sites were greater than 0.8 km from a training site. Because the RHS models were developed using spotted owl territories from the 1996 time period, comparison with Test96 most directly addresses model accuracy. Comparison with independent spotted owl locations from 2006, however, enabled us to evaluate accuracy of the models when projected to a new time period (model transferability), and to investigate systematic shifts in RHS at spotted owl sites. These shifts may occur, for example, in areas where densities of barred owls have increased during the 1996 to 2006 period, and are displacing spotted owls from favorable habitat. If this is the case (as has been hypothesized), we might expect to see reduced use of RHS area at 2006 spotted owl sites, relative to 1996 values (see Methods: Spotted owl location data).

We obtained adequate (N ≥ 100) test samples for 2006 in four modeling regions. As data for additional modeling regions and Test96 become available, further evaluation of model accuracy should be conducted. Table C20 shows the proportions of spotted owl sites in each of five RHS "bins" for the training data (Train), and Test06. Because they allow comparison of RHS values across a gradient of relative habitat suitability, these comparisons are more informative than binary "correct classification" analyses.

**Table C-20.** Comparison of percentage of 1996 training sites versus test samples of 2006 spotted owl locations in 5 categories of Relative Habitat Suitability.

| | **Oregon Coast** | | **Western Klamath** | | **Eastern Klamath** | | **Redwood Coast** | | **Rangewide** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Train** | **Test** | **Train** | **Test** | **Train** | **Test** | **Train** | **Test** | **Train** | **Test** |
| **N** | 247 | 169 | 358 | 136 | 375 | 108 | 392 | 284 | 2742 | 916 |
| **RHS bin** | | | | | | | | | | |
| **0 – 0.2** | 7.3 | 7.1 | 8.7 | 2.2 | 6.1 | 4.6 | 4.8 | 3.2 | 6.1 | 4.6 |
| **0.2 – 0.4** | 19.0 | 23.1 | 18.2 | 19.8 | 14.1 | 20.4 | 13.8 | 12.7 | 16.5 | 17.8 |
| **0.4 – 0.6** | 35.6 | 35.5 | 38.5 | 46.3 | 38.4 | 39.8 | 42.1 | 44.7 | 36.7 | 41.8 |
| **0.6 – 0.8** | 32.8 | 30.2 | 33.5 | 30.8 | 38.7 | 35.2 | 37.2 | 37.7 | 36.7 | 33.8 |
| **0.8 – 1.0** | 5.3 | 4.1 | 1.1 | 0.74 | 2.7 | 0 | 2.0 | 1.8 | 4.0 | 1.2 |

**Model evaluation summary:**

All modeling regions' models were well calibrated and showed a quite similar pattern in terms of strength of selection (see Figure C5). Cross-validation results by modeling region showed that all models were relatively robust to the 25% iterative reduction in sample size (see Table C19). Lastly, comparison of model results with independent test data showed the models had good ability to predict spotted owl locations (Table C20), and performed well when projected to 2006 vegetation conditions. Overall, these evaluations suggest that our RHS models were robust and have good generality. Subsequently, we used the full dataset models.

**Interpretation of model output:**

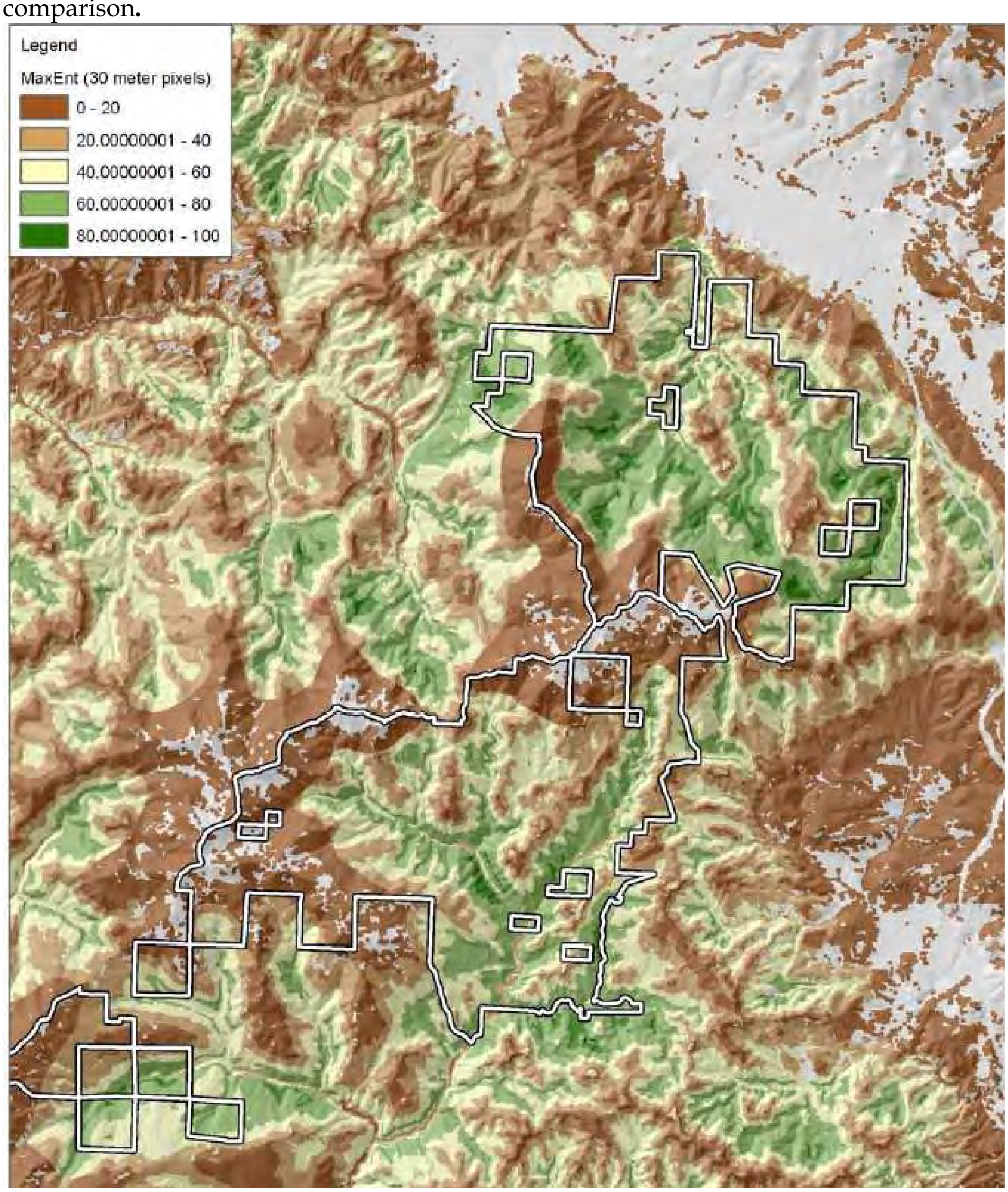
Elith *et al.* (2011) state that the MaxEnt logistic output is an attempt to estimate the probability that a species is present, given the environment (*i.e.*, the environmental conditions). For our purposes, we have taken a more conservative interpretation of the MaxEnt logistic output and interpret it to represent the relative habitat suitability (RHS) for nesting spotted owls within each modeling region. The map below (Figure C6) is the result of running each modeling region's best RHS model on each 30-m pixel within the region. That is, MaxEnt estimates a RHS value for each pixel based on the biotic and abiotic features within the 200-ha (~800 m radius) area around it (*i.e.*, based only on the variables in the best MaxEnt model for that modeling region). It is important to understand that a high RHS value is possible for a pixel that has little inherent value (*e.g.*, there are no trees in the 30x30 m focal pixel). It may, however, be that

the surrounding 200-ha has many of the attributes associated with high RHS. Similarly, a focal pixel could have many of the positive characteristics that spotted owls generally select for, but it receives a low RHS value owing to the surrounding 200-ha having few or none of the attributes associated with high RHS values.

As noted above the RHS map is designed to facilitate and enable a wide variety of processes, discussions and analyses, including section 7 consultation, implementation and evaluation of the efficacy of spotted owl conservation measures such as Recovery Action 10 and management of barred owls. This model likely has utility for a wider variety of uses and processes than we currently envision, and it can be refined by future advances in the understanding of spotted owl habitat associations.

Maps depicting the RHS model outputs for the range of the spotted owl are available at:
http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/Recovery/Library/Default.aspx#Files
Once there, click on "maps" and "AppendixCMaps.pdf" The layers can be turned on and off using the "layers" button in the upper left-hand corner. The RHS values are the base layer on this map.

**Figure C-6**. Map depicting Relative Habitat Suitability from MaxEnt model. Higher suitability habitat conditions are indicated by darker green areas; brown colors denote lower suitability. Outline of the Mount Ashland Late-successional Reserve is shown for comparison**.**



## Modeling Process Step 2 – Develop a spotted owl conservation planning model, based on the habitat suitability model developed in Step 1, and use it to design an array of habitat conservation network scenarios.

Because the RHS maps from Step 1 consisted of finely-distributed patterns of habitat suitability across the spotted owl's geographic range, we also wanted to provide a rigorous, repeatable method for aggregating habitat value into habitat conservation networks. We used the conservation planning model "Zonation" (Moilanen and Kujala 2008) to develop a spotted owl conservation planning model which can be used to design an array of habitat conservation network scenarios. To test this model we mapped a series of alternative spotted owl conservation network scenarios based on a series of rule-sets (*e.g.*, varying land ownership categories, the inclusion of existing reserves, identifying a specific amount of "habitat value" to include). The primary output of a Zonation analysis of the landscape is a "hierarchical ranking" of conservation priority of all cells or pixels in the landscape. Zonation allows analysts to incorporate species-specific factors such as dispersal capabilities and response to habitat fragmentation into the ranking of cells, and also allows the inclusion of factors such as land ownership and status into various evaluations. It is important to recognize that the maps produced by Zonation represent user-defined scenarios that were evaluated and compared in subsequent population modeling to test this modeling process; they do not represent decisions about the size or distribution of habitat conservation areas. While Zonation uses the term "reserve" to describe the conservation areas it identifies, this term does not dictate the types of management actions that could occur in those areas.

Zonation produces a hierarchical prioritization of the landscape based on the conservation value or "habitat value" of cells. A cell's habitat value is a function of its "base" value (*i.e.*, its RHS value) as well as the value of cells surrounding it. Thus, two cells of identical RHS may have different habitat value depending on how many other high, medium, and low value cells are nearby. The term habitat value therefore incorporates a larger spatial context than does RHS. Hierarchical, in this case, means that the most valuable five percent is also within the most valuable 10 percent; the top two percent is within the top five percent, and so on. Zonation uses minimization of marginal loss as the criterion to decide which cell is removed, and iteratively removes the least valuable cells from the landscape until no cells remain. The order of cell removal and its proportion of the total habitat value are recorded and can later be used to select any top fraction of cells or habitat value, the best 10 percent of cells or the top 10 percent of habitat value, for example, of the landscape.

To ensure that spotted owls and their habitat would be well-distributed throughout their range (one of the goals for recovery), Zonation analyses were conducted separately for each modeling region. This modeling region decision also had the impact of ensuring that conservation areas would be better distributed across the range of the species.

Zonation allows analysts to identify specific areas of the landscape that represent a particular percentage of the total estimated habitat value to the species. An important attribute of the Zonation algorithm is that it attempts to produce "efficient" solutions. That is, it prioritizes cells into units that maximize the habitat value per unit area within the solution (Figure C7). For example, in one Zonation scenario, 70% of the habitat value existed on ~40% of the landscape.

**Figure C-7**. *Hypothetical* relationship between total size of habitat conservation system (x-axis) and percentage of habitat value "captured" (y-axis). Theoretically, the only way to capture 100% of the habitat value is to have the entire area to be considered reserve (or all areas with value >0). For this example, the entire area is ~ 19 million ha. In this example, a reserve system that is ~4 million ha "captures" ~50% of the habitat value, one that is ~9 million ha captures ~75% of the habitat value, etc.


Because Zonation is spatially explicit, in a GIS environment the user can control several aspects of how the program evaluates the distribution of habitat value. This enables the program to emulate important aspects of the species' life history, landscape pattern of habitat, and desired attributes of a habitat conservation network.

Zonation's **Distribution Smoothing** function is a species-specific aggregation method that retains high-value areas (pixels) that are better-connected to others, resulting in a more compact solution. The user specifies the area or "smoothing kernel" within which Zonation averages or smooths habitat values, based on a two-dimensional habitat density calculation, in accordance with attributes of an organism's movement patterns or abilities, such as home range area. We compared kernel sizes corresponding to the core use area (800 m radius), median home range (2100 m), and median dispersal distance (27.7 km; Forsman *et al.* 2002). The main difference in the resulting solutions from these three different settings is that the results from the kernel estimated from dispersal distance or home range were less fine-grained than the results from the kernel value estimated from a core area. Given that we are estimating habitat conservation network scenarios at relatively large scales, the coarser-grained (home range-derived kernel values) maps provided more discrete areas as estimated networks, and thus we used the home range scale kernel size.

Zonation's **Cell Removal Method** function allows users to control the spatial pattern or "grain" of priority areas by specifying whether cell removal begins around the edges of the analysis area or at cells scattered across the analysis area. The idea behind the "Edge Removal" setting is that it is more likely to result in connectivity of higher-value areas within the more central areas of the landscape. However, because cell removal is limited to the perimeters of large landscapes, the Edge Removal option can result in large blocks containing extensive areas of unsuitable habitat such as interior valleys and high mountain peaks. The "Edge Removal with Add Edge Points" option allows the user to randomly distribute a specified number of edge points where cell removal occurs within large landscapes. This setting allows more flexibility than edge removal and provides a greater chance that interior areas of poor-suitability habitat will be removed from the solution, and results in more finely-grained pattern of priority areas. The "No Edge Removal" option does not predispose Zonation to start cell removal from any particular area or region, but removes the lowest value cells in the landscape first, then the next lowest, and so on. This results in very finely-grained prioritized areas (and very long computer run times). We conducted side-by-side comparisons and found that Add Edge Points and No Edge Removal end up with nearly identical solutions (~95% overlap in identifying the top 25% habitat value areas in the landscape). To develop a series of alternative habitat conservation networks, we selected Add Edge Points, distributing 2,000 edge points into each modeling region.

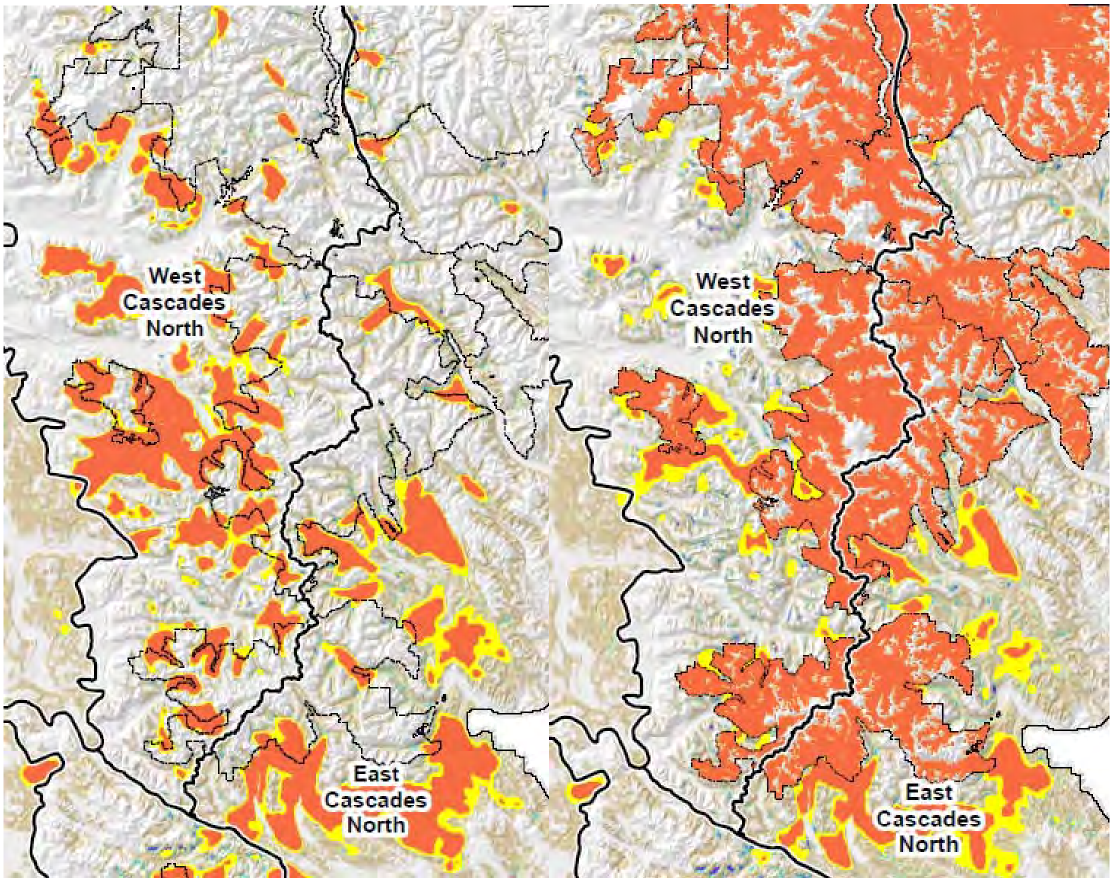
**Exclusion Areas** are areas that were excluded from the habitat suitability base maps prior to running Zonation. Examples are areas such as high elevation alpine areas as well as generally low elevation valley areas (*e.g.*, the Willamette Valley) that are considered incapable of supporting spotted owls. Including these areas in Zonation runs would give a false impression of habitat conservation block efficiency. That is, the algorithm would be able to remove large amounts of area (high elevation and valley areas) with no impact on the loss of spotted owl habitat value. Thus, we believed these areas should be masked out from the start. The GIS layer used to represent exclusion areas is the same one (mask) developed for the NWFP Monitoring Group (Davis and Dugger in press) and used in our MaxEnt modeling.

**Selection of values for conservation value ranking:** Zonation enables the user to specify the proportion of habitat value to display as maps of habitat conservation networks. Selection of the quantity of habitat value has a large influence on the size and distribution of habitat conservation networks. Because there is a near-infinite number of values that could be selected for evaluation, we compared results across a broad gradient of habitat values (20%, 30% 40%, 50%, 60%, 70%, and 80%), with the objective of identifying a smaller subset of reasonably diverse habitat conservation network scenarios for testing with the population model (see below). In addition, we compared habitat conservation networks from the above habitat values to the habitat values contained in existing networks such as spotted owl critical habitat (1992 and 2008) and the NWFP reserve network.

**Precedence Masking** allows the analyst to identify areas that must be or must not be included in the habitat conservation network. For example, existing protected areas such as Wilderness Areas and National Parks can be "forced" into the priority areas, regardless of their habitat value. Similarly, various land ownership categories can be "forced" out of priority areas. To accomplish this, the user identifies zones (land ownership, existing reserves, etc.) and ranks them by conservation priority (Zone 1, Zone 2, and so on) into a 'precedence mask'. In processing, Zonation removes the lowest value cells in Zone 1 first, , and continues by removing the next lowest value cell until all cells are removed in Zone 1 before moving on to Zone 2 and any potentially subsequent zones. Because the cells in Zone 2 are assigned a higher ranking, in terms of removal order, than those in Zone 1, they are disproportionately included in the solution. This process is repeated until all zones defined by the precedence mask have been fully evaluated. Zonation does not re-calculate or otherwise change the habitat value of a cell according to which zone it is in. Instead, identifying zones identifies discrete areas of the landscape that are to be given higher or lower priority of consideration for reasons other than the cells' habitat value.

The basis for precedence masking in Zonation is to allow factors such as land status to be incorporated into the landscape prioritization. For example, forcing existing National Parks and Wilderness Areas into habitat conservation networks would recognize that these areas exist as protected areas, and thus should be included in a habitat conservation networks regardless of their value to spotted owls. However, because we used Zonation to *help identify* areas estimated to provide the most conservation value for the spotted owl, we proceeded by first conducting an evaluation based purely on habitat value (unforced), and *then* evaluated how much overlap the resulting habitat conservation networks had with existing protected areas and other land designations or ownerships. Forcing existing reserves into priority areas will likely predispose Zonation to not find optimal solutions (*i.e.*, because some non-optimal areas are forced into the solution). For example, in areas such as the northern Cascades where high-value spotted owl habitat is relatively sparsely distributed, forcing Congressionally Reserved land allocations into priority areas resulted in an extremely inefficient network design (Figure C8).

**Figure C-8**. Comparison of Zonation 40% (orange) and 50% (yellow) solutions on all land ownerships (left) and with Congressional Reserves prioritized (right). Outlines of habitat conservation network solutions in the right frame correspond largely to National Park and National Forest boundaries.




After evaluating Zonation results employing a range of values for distributional smoothing, cell removal methods, ranking values, and land status and ownership prioritization, we selected habitat conservation network scenarios comprised of 30 percent, 50 percent, and 70 percent of habitat value as reference points. These scenarios sample along a gradient from somewhat smaller than the current habitat conservation network (NWFP) to a habitat conservation network approximately twice as large as the LSR network (Table C21). We recognize that the results of population modeling may indicate other Zonation scenarios that should or could be developed and tested (feedback loop in Figure C1). ***Also, it is important to recognize these scenarios are not recommendations for the specific size or location of habitat conservation blocks – they are only scenarios for the purpose of comparing to other scenarios to evaluate how they influence spotted owl population performance in the population simulation model.***

### Settings and Values Used in Zonation

**Distribution Smoothing:** Home range area (2100 m radius)
**Cell Removal Method:** Add Edge points (2000 points/modeling region)
**Exclusion Areas:** Used NWFP non-capable habitat mask from NWFP Monitoring
**Ranking Values:** Used 30%, 50%, and 70% of habitat value
**Precedence Masking:** Land ownership scenarios evaluated include:

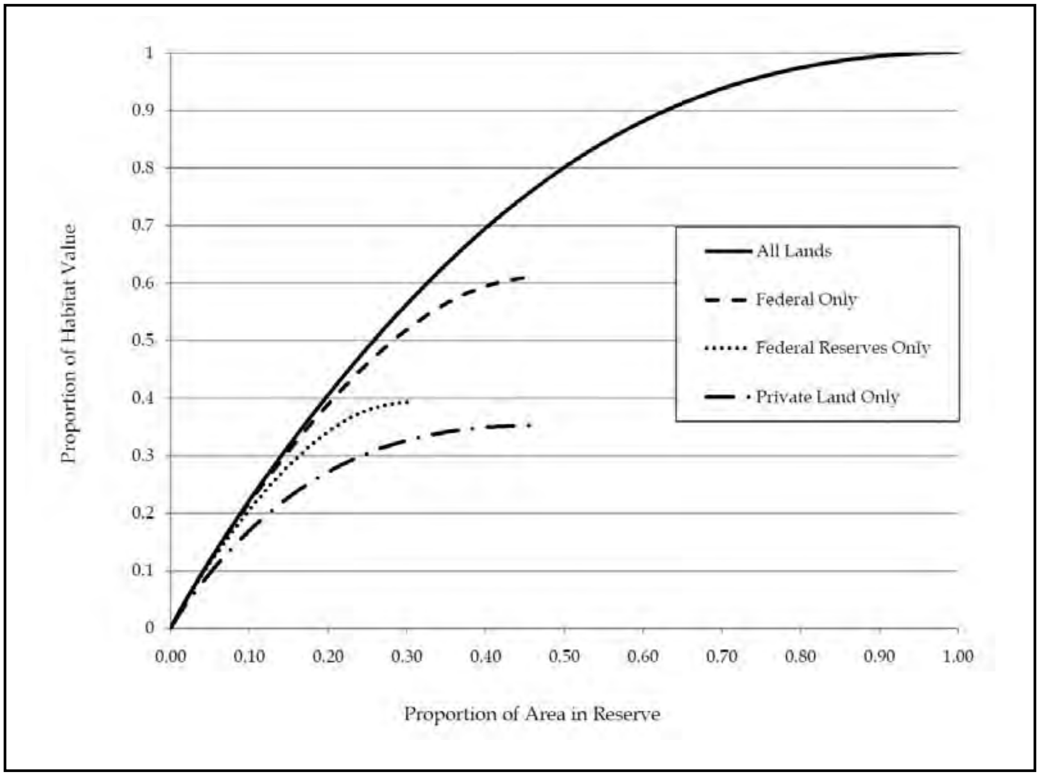
1) **No limit on inclusion** – No hierarchical masking - all land ownerships were allowed to be included and existing reserves were not forced into the priority areas. This scenario was chosen to represent the potential of the entire area to provide for spotted owls.

2) **Public lands only** – precedence masking was done such that non-public lands were removed first, and public lands were removed last. This had the effect of emphasizing reserves on public lands, but if the total amount of habitat value specified (*e.g.*, 50% or 70%) could not be acquired from cells in public lands, other lands could be included in the solution.

Maps depicting all of the initial Zonation scenarios are available at:
http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/Recovery/Library/Default.aspx#Files
Once there, click on "maps" and "AppendixCMaps.pdf" The layers can be turned on and off using the "layers" button in the upper left-hand corner.

Zonation outputs can be used to compare the contributions of different land classes (ownership, reserve status, etc.) based on the area and proportion of habitat value of each land class. Figure C9 depicts the relationship between area (proportion of the spotted owl's range) that could, hypothetically, be included in a habitat conservation network and the amount of spotted owl habitat value that various habitat conservation networks would contain among four categories: 1) all lands, which represents no limits on ownerships in the habitat conservation network; 2) Federal lands only, with no priority for currently existing reserves; 3) Federal reserves only, this scenario includes only NWFP reserves (Congressional Reserves and LSRs); and 4) private lands only; no reserves on Federal lands. These depictions are for demonstrative purposes only, not recommendations. They are essentially asking what would be the conservation value to spotted owls if habitat conservation areas were restricted to various land ownership categories. For example, private lands constitute about 45 percent of the spotted owl's range and provide roughly 35 percent of the rangewide habitat value (RHS), whereas the NWFP reserve network provides 40 percent of rangewide habitat value on 30 percent of the area (Figure C9).

**Figure C-9**. Relationship between proportion of various land ownerships/categories (no restriction, Federal lands only, Federal reserves only, or private lands only) included in a habitat conservation network and proportion of spotted owl habitat value included in the habitat conservation network.




While Zonation outputs do not evaluate or predict potential spotted owl population sizes associated with different habitat conservation network scenarios, they nonetheless permit comparison of the sizes of existing reserve or conservation networks to possible habitat conservation areas, and enable additional comparisons to be made in a GIS environment. For example, Table C21 shows a comparison of network size, percent of spotted owl training locations from the habitat modeling that falls within various habitat conservation network scenarios, and percent of the top two Zonation habitat value ranks among 10 habitat conservation network scenarios. Table C22 shows the relationship the proportion of RHS bins within each of 20 Zonation and 4 non-Zonation habitat conservation network scenarios. The results show the efficiency with which Zonation selects high RHS areas.

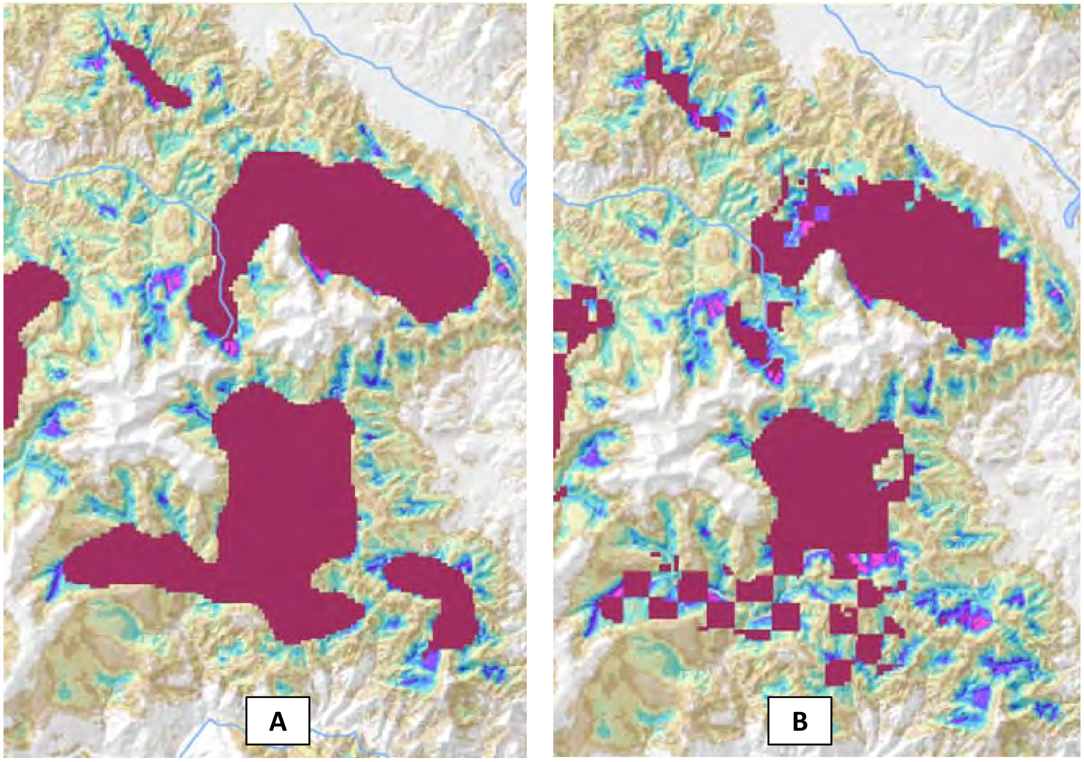
**Table C-21**. Comparison of area, percent of 1996 spotted owl sites used in model development, and percent of top 10% and 20% Zonation ranked habitat value for 10 spotted owl reserve scenarios.

| Network scenario | Network scenario size (million hectares) | Percent of 1996 spotted owl sites | Percent of top 10% Zonation-ranked | Percent of top 25% Zonation-ranked |
|---|---|---|---|---|
| NWFP | 6.63 | 46 | 56.7 | 55.2 |
| MOCA | 4.77 | 33 | 46.3 | 43.8 |
| 1992 Critical Habitat | 5.75 | 44 | 57.3 | 55.4 |
| 2008 Critical Habitat | 5.17 | 37 | 49.6 | 47.7 |
| Z30 All lands | 5.61 | 50 | 100 | 100 |
| Z50 All lands | 7.80 | 71 | 100 | 100 |
| Z70 All lands | 10.55 | 87 | 100 | 100 |
| Z30 Public lands | 5.57 | 51 | 94.9 | 91.3 |
| Z50 Public lands | 7.82 | 73 | 95.0 | 93.0 |
| Z70 Public lands | 11.24 | 88 | 98.9 | 98.0 |

**Table C-22**. Proportion of relative habitat suitability (RHS) bins represented among various habitat conservation network scenarios. Many more Zonation (Zall and Zpub) scenarios are presented in this table than in the remainder of the document. Zall = all lands available; public = Zpub lands prioritized in Zonation.

| | **Relative Habitat Suitability Bin** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Habitat Conservation Network Scenario** | **0 - 10** | **10 - 20** | **20 - 30** | **30 - 40** | **40 - 50** | **50 - 60** | **60 - 70** | **70 - 80** | **80 - 90** | **90 - 100** |
| **NWFP** | 0.22 | 0.26 | 0.31 | 0.36 | 0.41 | 0.46 | 0.51 | 0.57 | 0.63 | 0.58 |
| **MOCA** | 0.16 | 0.18 | 0.22 | 0.25 | 0.30 | 0.34 | 0.40 | 0.46 | 0.49 | 0.31 |
| **1992 Critical Habitat** | 0.17 | 0.22 | 0.28 | 0.33 | 0.38 | 0.44 | 0.50 | 0.57 | 0.66 | 0.57 |
| **2008 Critical Habitat** | 0.16 | 0.20 | 0.24 | 0.28 | 0.32 | 0.37 | 0.43 | 0.51 | 0.60 | 0.51 |
| **Z10all** | 0.00 | 0.00 | 0.02 | 0.03 | 0.07 | 0.16 | 0.33 | 0.54 | 0.70 | 0.89 |
| **Z10pub** | 0.00 | 0.01 | 0.02 | 0.04 | 0.08 | 0.16 | 0.30 | 0.51 | 0.68 | 0.83 |
| **Z20all** | 0.00 | 0.02 | 0.05 | 0.10 | 0.19 | 0.35 | 0.57 | 0.77 | 0.89 | 0.99 |
| **Z20pub** | 0.00 | 0.03 | 0.06 | 0.11 | 0.20 | 0.34 | 0.54 | 0.73 | 0.85 | 0.90 |
| **Z30all** | 0.01 | 0.05 | 0.11 | 0.20 | 0.33 | 0.53 | 0.74 | 0.89 | 0.95 | 1.00 |
| **Z30pub** | 0.01 | 0.06 | 0.13 | 0.21 | 0.34 | 0.51 | 0.70 | 0.83 | 0.90 | 0.91 |
| **Z40all** | 0.01 | 0.09 | 0.19 | 0.32 | 0.49 | 0.69 | 0.85 | 0.94 | 0.98 | 1.00 |
| **Z40pub** | 0.02 | 0.11 | 0.22 | 0.34 | 0.48 | 0.66 | 0.80 | 0.88 | 0.92 | 0.91 |
| **Z50all** | 0.02 | 0.15 | 0.30 | 0.46 | 0.63 | 0.81 | 0.92 | 0.98 | 0.99 | 1.00 |
| **Z50pub** | 0.04 | 0.21 | 0.35 | 0.47 | 0.61 | 0.75 | 0.85 | 0.90 | 0.92 | 0.91 |
| **Z60all** | 0.04 | 0.24 | 0.43 | 0.61 | 0.77 | 0.90 | 0.96 | 0.99 | 1.00 | 1.00 |
| **Z60pub** | 0.12 | 0.37 | 0.48 | 0.58 | 0.70 | 0.82 | 0.89 | 0.92 | 0.93 | 0.92 |
| **Z70all** | 0.08 | 0.38 | 0.59 | 0.75 | 0.87 | 0.95 | 0.99 | 1.00 | 1.00 | 1.00 |
| **Z70pub** | 0.25 | 0.47 | 0.59 | 0.70 | 0.81 | 0.90 | 0.94 | 0.97 | 0.98 | 1.00 |
| **Z80all** | 0.15 | 0.57 | 0.75 | 0.87 | 0.95 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Z80pub** | 0.32 | 0.61 | 0.73 | 0.83 | 0.91 | 0.96 | 0.98 | 0.99 | 1.00 | 1.00 |
| **Z90all** | 0.31 | 0.80 | 0.91 | 0.97 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Z90pub** | 0.47 | 0.79 | 0.88 | 0.95 | 0.98 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Z100all** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Z100pub** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

**Figure C-10**. Example Zonation output map of the Mount Ashland, OR, area, depicting 30 percent of habitat value in red on all lands (A) and on Federal lands only (B).




## Modeling Process Step 3 - Develop a spatially explicit spotted owl population model that reliably predicts relative responses of spotted owls to environmental conditions, and use it to test the effectiveness of habitat conservation network scenarios designed in step 2 in recovering the spotted owl. The simulations from this spotted owl population model are not meant to be precise estimates of what will occur in the future, but provide information on comparative trends predicted to occur under differing habitat conservation scenarios.

To meet this objective, the modeling team elected to use a spatially explicit, individual-based modeling approach. While other approaches such as population level population viability analysis (PVA) and metapopulation models have been used for evaluating spotted owl populations, we required an approach that enabled comparison of a wide range of spatially explicit conditions such as variation in habitat conservation networks. Dunning *et al.* (1995) wrote the following regarding spatially explicit population models:

> *"Spatial models, structured and parameterized according to a species' life history, allow one to explore the efficiency of various reserve designs. The models can be*

> *used to estimate the potential effects on a species' persistence by systematically varying factors such as the percentage of the landscape that is suitable habitat, and the size, shape, and spacing of habitat patches. The addition of marginal (i.e., sink) habitat to a reserve can be assessed for negative effects on a managed population (Pulliam and Danielson 1991). These exercises can be done on artificial landscape maps to explore general reserve design principles (Lamberson et al. 1992, 1994) or on GIS-based maps that incorporate land-use and ownership constraints (Murphy and Noon 1992, Noon and McKelvey 1992)."*

Individual-based models (IBMs) allow for the representation of ecological systems in a manner consistent with the way ecologists view such systems as operating. That is, emergent properties such as population increases or declines are the result of a series of effects and interactions operating at the scale of individuals. Individuals select habitat based on what is available to them, disperse as a function of their individual circumstance (age), compete for resources, etc.

Grimm and Railsback (2005) noted that IBMs need to be simple enough to be practical, but have enough resolution to capture essential structures and processes. The spotted owl is perhaps the most studied raptor in the world, and thus there exists a tremendous quantity and quality of data (*e.g.*, vital rates are evaluated in a meta-analysis for several long-term demographic study areas every 5 years; *e.g.*, Anthony *et al.* 2006, Forsman *et al.* (2011)); habitat selection (see review by Blakesley 2004) has been thoroughly evaluated; large numbers of individuals have been followed during dispersal (Forsman *et al.* 2002); among many other aspects of the species' ecology. The spotted owl is therefore ideally suited for spatially explicit IBM. Bart (1995), however, noted that the question "Does the model improve our ability to make decisions?" needs to be explicitly considered. The modeling team believes that the spatially explicit IBM HexSim, which is parameterized largely with empirically-derived values from spotted owl studies, improves our ability to make land management decisions, and therefore we have decided to use this approach.

**The HexSim Model:**

HexSim (Schumaker 2011) was designed to simulate a population's response to changing on-the-ground conditions by considering how those conditions influence an organism's survival, reproduction, and ability to move around a landscape. The modeling team developed a HexSim spotted owl scenario based on the most up-to-date demographic data available on spotted owls (Forsman *et al*. 2011), published information on spotted owl dispersal, and home range size as well as on parameters for which less empirical information was available (see below). Initially, the HexSim spotted owl model allows users to evaluate the efficacy of existing conservation strategies, under currently-estimated barred owl impacts and with currently-estimated habitat conditions, to meet recovery goals. Subsequently, the model serves as a consistent framework into which variation in spatial data layers (*e.g.*, reserve or conservation block boundaries, different assumptions about habitat conditions (RHS) inside and outside of reserves or

blocks, different assumptions about RHS change on public versus private lands, and different assumptions about the impact of barred owls among modeling regions) can be introduced. Comparison of estimates of simulated spotted owl population performance estimates across the range of scenarios incorporating variation in habitat conservation network sizes, habitat trends, and barred owl influence, can inform evaluations of habitat conservation networks and other conservation measures designed to lead to spotted owl recovery.

In very general terms, we tried to design the model to answer the following questions: (1) Given current circumstances (reserves, habitat, barred owls, spotted owl demographic rates, etc.), is recovery of the spotted owl likely in the foreseeable future?; (2) Given current estimates of habitat, barred owls, and spotted owl demographics, is recovery of the spotted owl likely in the foreseeable future under different habitat conservation network scenarios?; and (3) To what degree would management of habitat and barred owls contribute to or detract from reaching spotted owl recovery goals under a range of habitat conservation networks and management scenarios? Evaluation and ranking of the population simulation results from the model obtained across a range of habitat conditions, barred owl effects, and conservation network scenarios, and comparison with established recovery criteria, should provide important insight into these questions. **The HexSim model is available at: www.epa.gov/hexsim.**

**HexSim Overview:**

HexSim is a spatially explicit, individual-based computer model designed for simulating terrestrial wildlife population dynamics and interactions. HexSim is a generic life history simulator; it is not specifically a spotted owl model. HexSim was designed to quantify the cumulative impacts to wildlife populations of multiple interacting stressors.

HexSim simulations are built around a user-defined life cycle. This life cycle is the principal mechanism driving all other model processing and data needs. Users develop the life cycle when initially setting up a simulation. The life cycle consists of a sequence of life history events that are selected from a list. This event list includes survival, reproduction, movement, resource acquisition, species interactions, and many other actions. Users can impose yearly, seasonal, daily, or other time cycles on the simulated population. Each event can work with all, or just a segment of a population, and events can be linked to static or dynamic spatial data layers. Each life cycle event has its own data requirements. Simple scenarios may use few events with minimal parameterization and little spatial data. When more complexity is warranted, HexSim allows a great deal of data and behavior to be added to its simulations.

HexSim scenarios include descriptions of one or more populations, spatial data needs, life cycle definitions, event data, and basic simulation criteria such as the number of replicates and time steps. Each population is composed of individuals, and individuals have traits that can change probabilistically, or based on age, resource availability, disturbance, competition, etc. HexSim also includes optional genetics and heritable traits (though these were not used for the spotted

owl model). The use of traits allows members of the simulated population to have unique properties that change in time and space. Traits also allow populations to be segregated into classes, such as males and females, fitness categories, disease categories, etc. Combinations of trait values can be used to stratify events such as survival, reproduction, movement, etc.

Traits are a fundamental part of HexSim scenarios. Traits can be used to control most life cycle events because events can be stratified by trait combinations. For example, a movement event might be set up to operate only on a fledgling stage class. Or a survival event might assign mortalities based on the values of a trait that reflects resource acquisition. In addition, one trait's values can also be influenced by multiple other traits, which makes it possible to set up stressor interactions and complex feedback loops. Traits can also be used to capture interactions such as parasitism, competition, mutualism, breeding, etc.

**Overview of the Spotted Owl Scenario**

Because females are the most influential sex in terms of population dynamics, the HexSim spotted owl scenario is a females-only model. The life cycle is simple except that the acquisition of resources by individual spotted owls is spatially stratified, and thus somewhat complex. The scenario depends on two static spatial data layers; one representing the distribution and relative suitability of habitat, and an "exclusion layer" to prevent spotted owls from moving out into the Pacific Ocean, or into areas outside of their geographic range .

An additional layer comprised of the boundaries of both the modeling regions and demographic study areas (DSAs were used to generate HexSim reports (*i.e.*, we extracted information about spotted owls in DSAs as well as within modeling regions and for all modeling regions overall), had no effect on the simulated population. All spatial data layers are converted to grids consisting of 86.6- ha hexagons. To the extent possible, simulation parameter values were estimated based on published empirical data.

The HexSim simulations began with 10,000 spotted owls being virtually introduced into the study landscape. The initial population's ages were randomly distributed, and they were placed preferentially into areas of high RHS. Once initialization was complete, individual spotted owls were subjected to the event cycle shown in Figure C11. The year begins with each individual becoming a year older. Next, floaters (spotted owls without a territory) prospect for a territory. This is followed by reproduction and fledgling dispersal. Dispersing fledglings do not prospect for a territory.

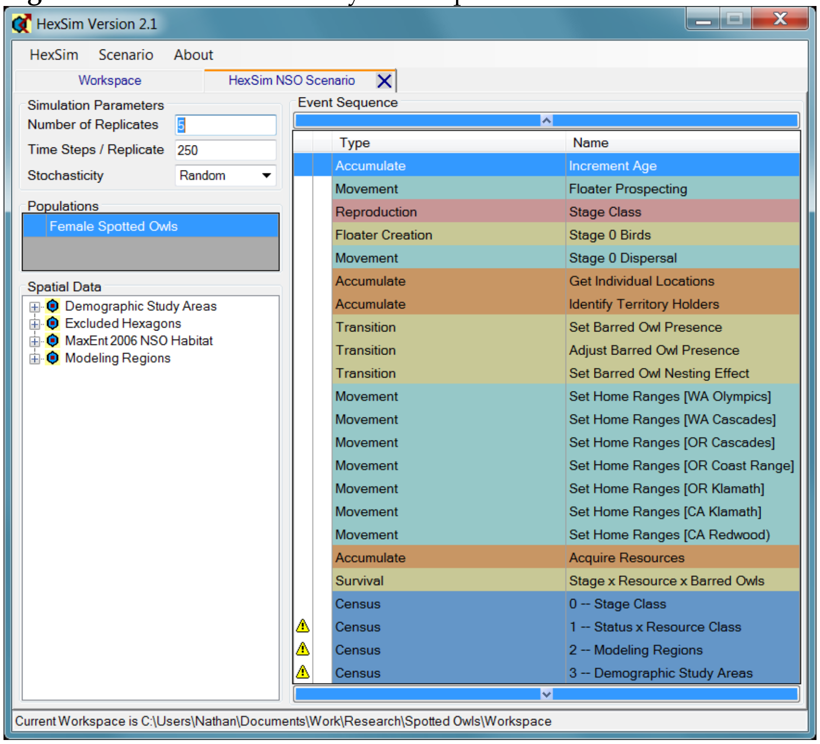
We assumed that the RHS map developed in MaxEnt was a proxy for the amount of resources available to spotted owls within each hexagon. Because nesting spotted owls showed relatively strong selection for some RHS categories and against others (see Figure C5), we reasoned that this selection was based on a combination of factors (including, but not limited to, those we included as covariates in our models) that influence spotted owl natural selection. That is, spotted owls select some areas and avoid other areas in order to maximize their

survival and reproductive success. Spatially-explicit data on competitors, prey, predators and other factors influencing spotted owls were unavailable, and thus we were unable to incorporate more direct measures of resource quantity and quality.

In the HexSim Spotted Owl Scenario, a primary influence of RHS on simulated spotted owl populations occurs in territory acquisition (occupancy). To the extent that some areas aren't selected by spotted owls (or disproportionately selected against), habitat suitability acts to limit survival and reproduction (*i.e.*, spotted owls don't survive or reproduce in areas that they don't occupy). Subsequent to territory establishment, resource acquisition (RHS values) determines the resource class a spotted owl is placed in, which influences survival rates. Reproduction was not influenced by resource acquisition, and thus was not influenced by habitat quality. Individual studies (*e.g.*, Franklin *et al*. 2000) and meta-analyses have reported influences of habitat on survival and in some cases fecundity (see Forsman *et al*. 2011).

We recognized the importance of dispersal and habitats used by dispersing spotted owls in developing habitat conservation planning models. However, relatively little is known about the characteristics of areas used by dispersing spotted owls. In the spotted owl modeling effort, the modeling team therefore elected not to define or attempt to model dispersal habitat, but instead to rely on reasonable assumptions about the influence of relative habitat suitability (for nesting) on successful dispersal. Success (survival) of spotted owls dispersing through variable landscapes may be influenced by factors similar to those affecting territorial spotted owls (*e.g.* availability of prey, cover from predation, thermal stress) albeit at a different scale. Because the RHS values generated by MaxEnt retain the full gradient of habitat suitability (*i.e.* not 'thresholded' or categorized), it is reasonable to assume that relative habitat suitability is correlated with relative success of dispersal occurring in those areas (pixels). In HexSim, dispersing spotted owls are allowed to disperse through the full range of RHS values, with some degree of repulsion to the lowest RHS values.

**Figure C-11**. HexSim event cycle for spotted owls.




After floater spotted owls finish prospecting for territories, the modeling region they are in is recorded. Then the determination of whether each territorial spotted owl is in the presence of a barred owl is made probabilistically, with the probability of being in the presence of a barred owl dependent on the modeling region (Table C25). The region-specific probabilities for spotted owl exposure to barred owls were based on the proportion of spotted owl territories where barred owls were detected each year on the 11 DSAs (see Appendix B; Forsman *et al*. 2011). This decision is only made once per “bird-territory” (*i.e.*, once the decision is made for an individual spotted owl at a territory, the barred owl presence/absence is fixed for that territory until another spotted owl takes over the territory). All non-territorial spotted owls are placed in an ‘undetermined status’ category until they obtain a territory. A newly territorial spotted owl that has this undetermined status is assigned a "barred owl present" or "barred owl absent" status, based on the barred owl encounter probability for that modeling region.

Next, spotted owls that have the “barred owl present” status are placed in either a "*nesting normal*" or "*nesting halted*" class. At present, every spotted owl is placed into the *nesting normal* class. If spotted owls were assigned to the *nesting halted* class, they would not reproduce. Unlike the barred owl presence/absence trait described above, the *nesting normal* vs. *nesting halted* decision could be revisited every year, for every territorial spotted owl. Spotted owl floaters do not reproduce, so although they are always assigned to the *nesting normal* category, this has no impact on the simulation results. We mention these features (even when they aren’t used) that were built into the HexSim Spotted Owl Scenario

model to show how the model can adapt to and incorporate new information when it becomes available.

In the HexSim simulation, barred owls affect spotted owls through survival only. However, the simulation has been developed to facilitate a barred owl impact on spotted owl reproduction. This feature has not yet been used. It would also be possible to have barred owls impact habitat selection by spotted owls, or site fidelity. Neither of these processes has been implemented. Reproductive rates were obtained from Table 3 of Forsman *et al*. (2011). Those estimates were for time periods as long as 1985 to 2008 and as short as 1992 to 2008. It is generally agreed that barred owl populations have increased in most areas of the spotted owl's range over that time. Thus, to the degree that barred owls have an influence on fecundity, that influence is incorporated into these estimates.

Spotted owl reproduction is stratified by both stage class and nesting status (see above). Spotted owls that are in the *nesting halted* class have 100% probability of producing a clutch of size 0. Otherwise, the reproductive rates vary by stage class.

Spotted owl survival is stratified by barred owl presence, stage class, and resource class. Spotted owls in the barred owl present class have lower survival rates. Those in the barred owl absent, or undetermined classes, have higher survival rates.

At present, barred owls are not explicitly simulated, but are instead captured probabilistically. Accounting for barred owl impacts on spotted owl habitat selection or site fidelity would require that barred owls be actually located on the simulated landscape, and possibly even fully simulated within HexSim. The modeling team felt that sufficient data did not exist range-wide to permit either option to be incorporated into the current simulations. When such data become available, they can be integrated into the framework we have developed.

Next, each spotted owl establishes a home range. The simulated spotted owls have small defended territories, but large overlapping home ranges. Home range size varies with modeling region. The spotted owls extract resources from their home ranges, and thus they experience competition for resources from conspecifics. Finally, resource acquisition and survival are simulated. Survival varies based on stage class, resource acquisition class, and exposure to barred owls.

Home range sizes were set to the mean of the available regional-specific estimates (see summary in Schilling 2009). Spotted owl survival rates were based on study area-specific estimates from Forsman *et al*. (2011), with adjustment for the impact of barred owls across all study areas as calculated from the survival meta-analysis model containing an additive barred owl effect, also from Forsman *et al*. (2011).

## The Population Parameters

Three distinct component groups were involved in the specification of the HexSim spotted owl population. These involved a set of basic properties, the definition of several different population traits, and finally the establishment of rules for the spotted owl's use of space and resource needs. The basic properties were used to establish an initial population size of 10,000 spotted owls, and to define an exclusion layer. Individuals were initially placed into the best hexagons in the simulation landscape, but only one spotted owl was allowed per hexagon.

Seven traits were created as part of the spotted owl population definition. These traits track stage class, location (modeling region and possibly DSA), resource class, territory status (territorial vs. floater), exposure to barred owls, and barred owl impacts on spotted owl nesting. Table C23 shows each possible trait value.

The simulated spotted owls produced each year begin life at age zero, and stage class zero. Each year they transition into the next stage class. At age 3 they reach stage class three, which is the terminal stage class. The spotted owls always belong to one of three resource classes, depending on the amount of resources they are able to acquire from their home range. Resources are a function of the mean RHS of hexagons, derived from the MaxEnt models (see above). Spotted owls that acquire 2/3 or more of their resource target are placed in the high resource class. Those that attain less than 1/3 of their resource target are placed into the low resource class. All other spotted owls are placed into the medium resource class. Resource targets vary by modeling region, and are described below.

The territory status trait is used to record whether individual spotted owls own a territory, or are floaters. The barred owl presence trait categorizes individual spotted owls as being exposed, or unexposed, to a barred owl. This decision is made once for each territorial spotted owl. The barred owl nesting effect trait is used to assign a probability that exposure to a barred owl will cause a spotted owl to avoid nesting. This evaluation is repeated every year for every spotted owl.

**Table C-23**. Spotted owl scenario traits and value categories.

| Trait | Values |
|---|---|
| Stage Class | Stage 0 |
| | Stage 1 |
| | Stage 2 |
| | Stage 3 |
| Resource Class | Low |
| | Medium |
| | High |
| Territory Status | Floater |
| | Territorial |
| Barred Owl Presence | Pending |
| | Absent |
| | Present |
| Barred Owl Nesting Effect | Normal |
| | Halted |

| Trait | Values |
|---|---|
| Modeling Region | North Coast Olympics |
| | Oregon Coast |
| | East Cascades South |
| | East Cascades North |
| | West Cascades North |
| | West Cascades Central |
| | West Cascades South |
| | Klamath East |
| | Klamath West |
| | Inner-California Coast Range |
| | Redwood Coast |

| Trait | Values |
|---|---|
| DSA | Cle Elum |
| | Coast Ranges |
| | HJ Andrews |
| | Klamath |
| | Olympic |
| | Rainier |
| | South Cascades |
| | Tyee |
| | Warm Springs |
| | Wenatchee |
| | Hoopa |
| | Marin |
| | NW California |
| | Simpson |

The modeling region and demographic study area traits are used to track individual spotted owl locations. The 11 modeling regions are space-filling and non-overlapping. Each individual spotted owl occupies one modeling region at any one time. If a spotted owl territory spanned multiple modeling regions, it was assigned to the region in which the majority of its territory hexagons fell. The demographic study areas (DSAs) take up just a fraction of the landscape. So at any moment most spotted owls will not be in a DSA. Resource targets (explained below) and home range size vary by modeling region.

The population parameters also control individual's use of space. The simulated spotted owls had territory sizes of no more than three 86.6-hectare hexagons. This territory size represents a reasonable approximation of a spotted owl core

area (see discussion of spatial scale above). Hexagons had to have at least a score of 35 (out of 90 possible) to be usable in forming a territory. We decided on a minimum score of 35 after evaluating the scores of hexagons overlaid on 3,790 spotted owl nest sites. We evaluated the score for the focal hexagon (the one in which the nest resided), the second, and third closest hexagons, as well as the mean scores of the first, second, and third hexagons. More than 75% of the nest sites were in hexagons with scores >35. Similarly, 73% of the spotted owl sites had a mean score >35 for the focal, second, and third closest hexagons. Although other scores might be reasonable, we reasoned that increasing the score would unreasonably inhibit settlement on suitable areas, whereas decreasing the score would result in unrealistic densities in areas with relatively low RHS. Territory size had little significance for the simulated population dynamics, as the spotted owls derive resources from their home ranges. The territories served as a core area around which home ranges could be constructed. Territories, in the HexSim simulations, were exclusively used areas, whereas the remainder of the home range area could overlap with that of neighboring spotted owls.

Each simulated spotted owl has a resource target, which controlled how much resource it must have access to in order to be placed into the highest resource class. The resource targets vary by modeling region. Spotted owls that acquire 2/3 or more of their resource target are placed into the high resource acquisition class. Those that attain less than 1/3 of their resource acquisition target are placed into the low resource acquisition class. All other spotted owls end up in the medium resource acquisition class. The resource targets are listed in Table C24.

**Table C-24.** Estimated resource targets based on RHS values at 3,790 spotted owl locations.

| Modeling Region | Home Range Size ha (# hexagons) | Resource Target |
|---|---|---|
| North Coast Olympics | 11,052 (128) | 1250 |
| East Cascades North | 7,258 (84) | 1000 |
| West Cascades North | 7,258 (84) | 1250 |
| West Cascades Central | 7,258 (84) | 1250 |
| Oregon Coast | 4,123 (48) | 375 |
| West Cascades South | 3,949 (46) | 375 |
| Inner CA Coast Range | 3,165 (37) | 375 |
| East Cascades South | 3,033 (35) | 750 |
| Klamath East | 3,033 (35) | 375 |
| Klamath West | 3,033 (35) | 375 |
| Redwood Coast | 1,173 (14) | 250 |

## The Event Sequence

There are 23 events in the HexSim spotted owl scenario. Not all of these events modify the population, and some have similar or related functions. These events are described in turn below. Each event is listed by type (*e.g.*, movement) and specific name (in square brackets).

Accumulate [Increment Age]

This event makes each individual one year older. As a result, stage 0 individuals will move into stage 1, stage 1 individuals will move into stage 2, and stage 2 individuals will move into stage 3.

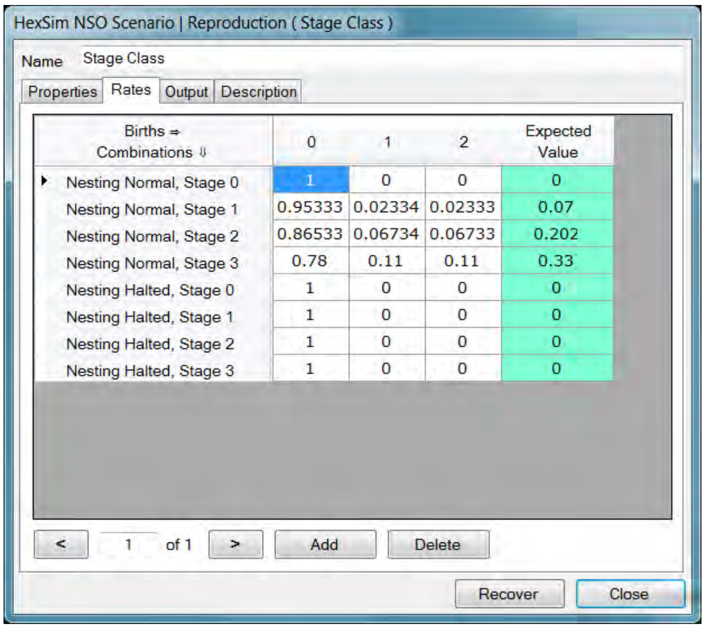
Movement [Floater Prospecting]

HexSim's movement event controls dispersal and prospecting behavior. But any one event may do either or both. This event only performs prospecting, but it does so for all spotted owls that are floaters (*i.e.*, those who do not own a territory). Individual floaters are allowed to search an area of up to 500 86.6 - hectare hexagons in search of a vacant area from which a territory could be constructed. The search strategy is imperfectly informed by resource availability. That is, spotted owls tended to construct home ranges from high RHS hexagons, but they did not select the best sites with certainty.

### Reproduction [Stage Class]

HexSim's reproduction module is parameterized by assigning probabilities to each possible clutch size. Reproduction is also stratified by traits. In this case, the maximum clutch size was set to 2, and reproduction rates were varied by stage class, and based on the Barred Owl Nesting Effect trait values. The reproductive rates used in the event are shown in Figure C12. The unperturbed (by barred owls) reproductive rates were obtained from Table 3 of Forsman *et al.* (2011).

**Figure C-12**. Estimated spotted owl reproductive rates by stage class.




| Births ⇒ Combinations ⇓ | 0 | 1 | 2 | Expected Value |
|---|---|---|---|---|
| Nesting Normal, Stage 0 | 1 | 0 | 0 | 0 |
| Nesting Normal, Stage 1 | 0.95333 | 0.02334 | 0.02333 | 0.07 |
| Nesting Normal, Stage 2 | 0.86533 | 0.06734 | 0.06733 | 0.202 |
| Nesting Normal, Stage 3 | 0.78 | 0.11 | 0.11 | 0.33 |
| Nesting Halted, Stage 0 | 1 | 0 | 0 | 0 |
| Nesting Halted, Stage 1 | 1 | 0 | 0 | 0 |
| Nesting Halted, Stage 2 | 1 | 0 | 0 | 0 |
| Nesting Halted, Stage 3 | 1 | 0 | 0 | 0 |

The column headings in Figure C12 correspond to clutch sizes. The rows contain all of the permutations of the two trait values. The right-most column shows the expected values, which, in a females-only model, equal fecundities. Individuals whose nesting has been halted by a barred owl are assigned a 100% probability of having a clutch size of zero. The same is true for stage class 0 individuals. Otherwise, the probabilities of having clutches of size 1 and 2 were set as equal as possible, to whatever value was necessary to produce the fecundity values reported in Forsman *et al.* (2011). Finally, the probability of having a clutch of size zero was set so that each row summed to exactly 1.0.

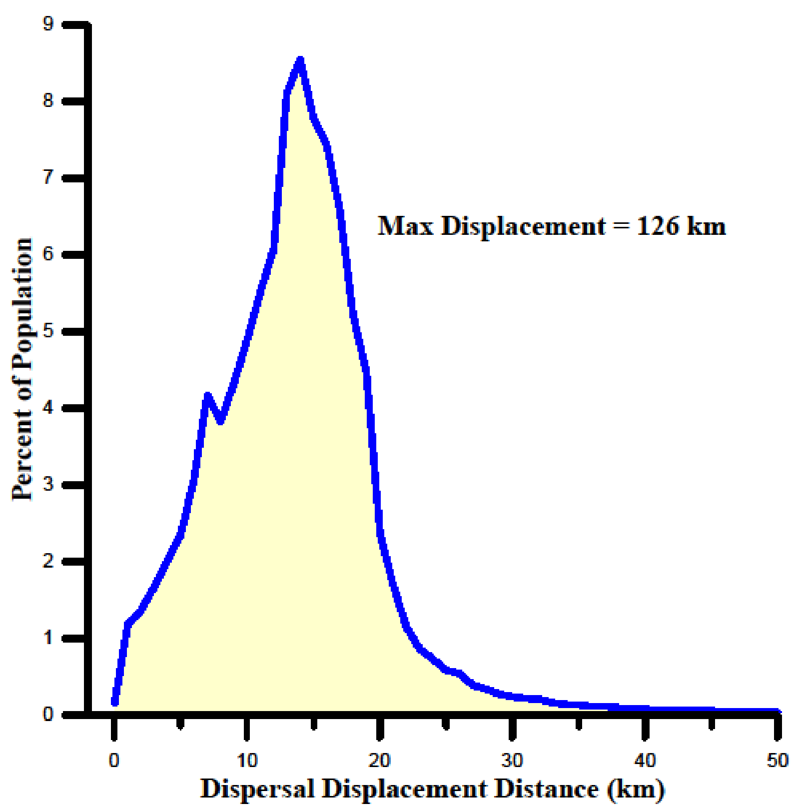
### Floater Creation [Stage 0 Birds]

In HexSim, recruits become a co-owner of their mother's territory. They will disperse from their natal territory when forced to by a floater creation event at the end of Year 1. This floater creation event removes all stage 0 birds from their natal groups. These animals disperse in the next event.

Movement [Stage 0 Dispersal]

HexSim's movement event controls dispersal and prospecting behavior. Any one movement event may do either or both. This event strictly performs dispersal for stage class 0 spotted owls. The dispersing birds move with moderate auto-correlation until they encounter enough resource that a territory may be constructed (see above). Territory construction does not actually take place at this time. The dispersers are limited to moving 250 km total distance. The birds have a slight repulsion to lower RHS areas of the landscape, but are not prevented from moving into zero-valued hexagons. Figure C13 shows an example of the distribution of simulated dispersal displacement distances produced by this movement event. These data were gathered from five replicate simulations, for years 100-250. The total number of dispersal events in this period was approximately 852,000. The shape of this frequency distribution will change if either the rules for stopping (3 territory-quality hexagons encountered in succession) or the degree of autocorrelation (50%) are modified.

**Figure C-13**. Distribution of 852,000 simulated Year 1 dispersal distances.



Accumulate [Get Individual Locations]

This event records which modeling region each spotted owl is in. If an individual falls within a demographic study area then this event will captures that information, as well.

Accumulate [Identify Territory Holders]

This event updates a trait that segregates into two classes: floaters and territory-holders.

Transition [Set Barred Owl Presence]

This transition event assigns values to the Barred Owl Presence trait. Each modeling region was assigned a separate barred owl encounter probability, based on field data illustrating the proportion of spotted owl territories on DSAs where a barred owl was documented each year (Appendix B; Forsman *et al.* 2011). Using these probabilities, this event places each territorial spotted owl into one of two classes. The classes indicate whether the spotted owl is exposed to a barred owl or not. Once this determination is made for a specific spotted owl, it is not changed until that spotted owl dies or otherwise leaves the territory. The probabilities that were used are shown in Table C25.

**Table C-25.** Barred owl encounter probabilities estimated from Forsman *et al.* (2011).

| Region | Encounter Probability |
|---|---|
| North Coast Olympics | 0.505 |
| East Cascades North | 0.296 |
| West Cascades North | 0.320 |
| West Cascades Central | 0.320 |
| Oregon Coast | 0.710 |
| West Cascades South | 0.364 |
| Inner CA Coast Range | 0.213 |
| East Cascades South | 0.180 |
| Klamath East | 0.245 |
| Klamath West | 0.315 |
| Redwood Coast | 0.205 |

Transition [Adjust Barred Owl Presence]

This transition event simply removes the barred owl presence designation from floater spotted owls. This way, if a spotted owl was to give up its territory and leave, it would not retain its barred owl presence / absence designation. In the present scenario territorial spotted owls have perfect site fidelity, so this event has no impact.

Transition [Set Barred Owl Nesting Effect]

This transition event uses the barred owl presence trait to set the value of a barred owl nesting effect trait. This allows spotted owls that are exposed to a barred owl to be placed into a non-nesting category with some probability. As this probability increases from zero, barred owls have an increasingly strong influence over spotted owl nesting rates, and hence reproductive output. In these simulations, the barred owl effect on spotted owl nesting was set to zero.

Movement [Set Home Ranges]

Eight different movement events are used to set home range sizes differently based on modeling region. These movement events only establish home ranges for territorial spotted owls. The home range sizes used are listed in Table C26. Spotted owls acquire resources from their home ranges, and the home ranges for different birds may overlap; territories however, cannot overlap. This results in competition among spotted owls for resources. Spotted owl home ranges were always contiguous, but their shapes were not constrained. The home range sizes used were developed from the published results of many field studies, and were compiled by the modeling team.

**Table C-26.** Spotted owl home range sizes used in population modeling.

| Region | Home Range Size (in hexagons) |
|---|---|
| North Coast Olympics | 128 |
| East Cascades North | 84 |
| West Cascades North | 84 |
| West Cascades Central | 84 |
| Oregon Coast | 48 |
| West Cascades South | 46 |
| Inner CA Coast Range | 37 |
| East Cascades South | 35 |
| Klamath East | 35 |
| Klamath West | 35 |
| Redwood Coast | 14 |

Accumulate [Acquire Resources]

This "accumulate event" assigns individual spotted owls to a resource class, based on how much resource they acquire from their home ranges. Habitat suitability and quantity, plus competition with conspecifics will dictate what resource class individual spotted owls end up in.

Survival [Stage x Resource x Barred Owls]

The survival event is stratified by stage class, resource class, and exposure to barred owls (which is binary). The survival rates that were used are shown in Table C27. The derivation of these values is discussed in a separate section below.

Census [x 4]

Four census events are used to track the number of spotted owls by stage class, resource class, modeling region, and demographic study area.

**Table C-27.** Estimated survival rates of spotted owl based on stage class, resource class, and barred owl effect.

| Without Barred Owls | | | With Barred Owls | | |
|---|---|---|---|---|---|
| **Stage Class** | **Resource Class** | **Survival Rate** | **Stage Class** | **Resource Class** | **Survival Rate** |
| Stage 0 | Low | 0.366 | Stage 0 | Low | 0.28 |
| | Medium | 0.499 | | Medium | 0.413 |
| | High | 0.632 | | High | 0.546 |
| Stage 1 | Low | 0.544 | Stage 1 | Low | 0.458 |
| | Medium | 0.718 | | Medium | 0.632 |
| | High | 0.795 | | High | 0.709 |
| Stage 2 | Low | 0.676 | Stage 2 | Low | 0.590 |
| | Medium | 0.811 | | Medium | 0.725 |
| | High | 0.866 | | High | 0.780 |
| Stage 3 | Low | 0.819 | Stage 3 | Low | 0.733 |
| | Medium | 0.849 | | Medium | 0.763 |
| | High | 0.865 | | High | 0.779 |

## Spatial Data

The Baseline HexSim spotted owl scenario uses four different map files. All four maps are static (they do not change with time), and each is made up from 538,395 hexagons arranged in 1430 rows and 377 columns. Individual hexagons are 1000 meters in diameter, and 86.6 hectares in area. The spatial data were developed by sampling raster imagery, using a tool that is built into the HexSim model. The sampling process involves intersecting a grid of hexagonal cells with a raster image, and then computing a per-hexagon mean from a series of weights assigned to the land cover classes present in the raster data.

The habitat map (*MaxEnt 2006 NSO Habitat)* depicts spotted owl RHS values developed using MaxEnt in Step 1 (see above). In HexSim, each pixel was assigned a weight equal to its RHS score. Pixel scores ranged between zero and 97. Thus when the HexSim RHS map was constructed from this raster file, the largest possible hexagon score was 97.00; this upper limit was never realized because each hexagon's value represented an average of the pixels underneath it. The hexagons in the HexSim RHS

map vary between 0.00 and 90.37. Hexagon scores were assumed to be proxies for the value of resources available to NSOs within the hexagon.

The habitat map (*MaxEnt 2006 NSO Habitat)* captures spotted owl resource quality, and was derived from RHS values developed using MaxEnt in Step 1 (see above). In HexSim, each land cover class was assigned a weight equal to its category ID. The category IDs ranged between zero and 97. Thus when the HexSim resource quality map was constructed from this raster file, the best possible hexagon score was 97.00; this upper limit was never realized because each hexagon's value represented an average of the pixels underneath it. The hexagons in the HexSim resource quality map vary between 0.00 and 90.37.

A map delineating the study area (*Excluded Hexagons)* was binary, with ones being assigned to each hexagon within the range of the spotted owl, and zeros elsewhere. Simulated spotted owls were not allowed to move into hexagons that were zero-valued in this map. This map included boundaries to the study area, such as the Pacific Ocean and other areas outside of spotted owl's range, or outside our area of inquiry (*e.g.*, the spotted owl's range in British Columbia).

The final two maps depict the locations of the modeling regions and DSAs. The map called *Modeling Regions* breaks the range of the spotted owl up into 11 different regions. This map was used to identify which region individual spotted owls occupied, because each modeling region had different resource requirements and home range sizes. Similarly, a map called D*emographic Study Areas* indicates the locations of 14 different DSAs.

## Survival Rates

The survival event is stratified by stage class, resource class, and exposure to barred owls. To begin with, 9 survival rates (estimated apparent survival) were derived from Table 12 in Forsman *et al.* (2011). Because true adult survival is unknown we made the assumption that apparent adult survival is equal to, or a reliable surrogate for, true adult survival. These rates corresponded to the three oldest stage classes x 3 resource classes. Forsman *et al.* (2011) provided stage class-specific survival estimates for each of 11 DSAs. For each study area and stage class, mean apparent survival values for males and females were provided. We computed the mean of each pair and identified the smallest and largest of these mean values. For any given stage class, the smallest mean value was assigned to individuals in the low resource class. Likewise, the largest stage-specific mean value was assigned to individuals in the high resource class. The stage-specific survival rates for individuals in the medium resource class were set equal to the mean taken over all of the survival estimates present in Table 12 of Forsman *et. al* (2011) for that stage class. Through this process survival rates were obtained for stage 1-3 spotted owls in all three resource classes.

Stage class 0 survival estimates were taken from Franklin *et al.* (1999: 27-28). This is the final report titled "Range-wide status and trends in northern spotted owl populations" that was written after a major workshop held in Corvallis, Oregon, in 1999 to estimate demographic rates of the subspecies. The estimates of juvenile

survival rates for three study areas from banding studies were adjusted to compensate for emigration rates, based on radio telemetry studies conducted by Eric Forsman (unpublished data). Mean, minimum and maximum juvenile survival rates were taken from this reference and used in the model. The mean value for Stage class zero was set to the midpoint between the minimum and maximum value.

Finally, survival rates were varied based on the presence or absence of barred owls, and the magnitude of their effect was based on the best meta-analysis model for survival with an additive barred owl covariate across all DSAs from Forsman *et al.* (2011). These values were stratified by both stage class and resource class.

## Evaluation of Model Calibration

The HexSim model simulated a females-only population of spotted owls throughout their range. The principal metric used to evaluate the model was the simulated population size. The numbers of female spotted owls were tracked range-wide, per modeling region, and also per DSA. The model's performance was assessed by comparing all three measures of simulated population size to field data. We compared simulation year 50 HexSim estimates to field data for 8 DSAs. For this comparison, we used the HexSim simulations during which barred owl impacts were inserted during year (or time-step) 40. After barred owl impacts were incorporated at time-step 40, they remained constant for the remaining 210 time-steps. For these simulations we did not attempt to back-cast barred owl "invasion" dynamics. Our "scenario", therefore, predisposed barred owl impacts to occur all at once, not incremented. We determined by inspection that simulation year 50 most closely represented the present day.

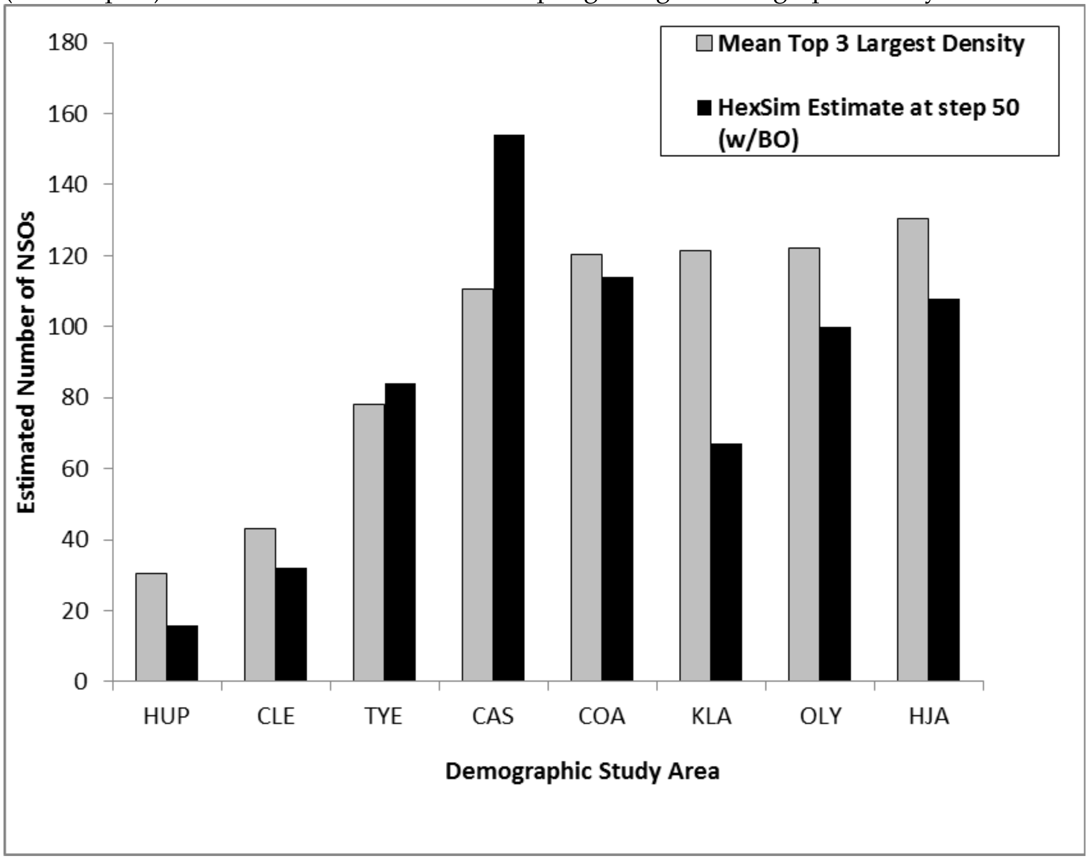
HexSim simulations are stochastic, and to quantify population size, the mean was taken from 5 replicate simulations. Each simulation was 250 time-steps (years) in duration. This does not suggest that spotted owl population sizes were forecasted 250 years into the future. Doing so would at minimum require performing the simulations with a series of maps illustrating habitat changes through time. In contrast, these initial simulations were performed with static data from year 0 to year 40, then (if changes were introduced) changes in barred owl or RHS were introduced and remained static until year 250. The length of the simulations (250 years) simply allowed a steady-state population size and trend to be estimated.

Most, but not all DSAs had data that could be used to approximate density of female spotted owls. Additionally, not all DSAs functioned as "density study areas", and they did not always sample spotted owls identically, nor present data consistently (among DSAs at least). Nonetheless, most DSA annual reports contained tables of historic data which revealed trends. For calibration purposes data from the following DSAs were used: Cle-Elum, Olympic, Oregon Coast, HJ Andrews, Tyee, Klamath, Cascades, and Hoopa. Several calibration iterations were performed by varying resource requirements one modeling region at a time.

Discrepancies in the fit between simulated and observed population size were addressed by varying the resource targets (described above). The resource targets were specified on a modeling-region basis, and they indicated how much resource an individual spotted owl living in a specific region would attempt to acquire. The resource targets were a proxy for resource availability, which varied from region to region and was not fully captured in the RHS maps. As the resource targets increased, individual spotted owl's needs for resources increased. An inability to acquire sufficient resources could cause spotted owls to drop into the lower resource acquisition classes, which would then lower their survival rates.

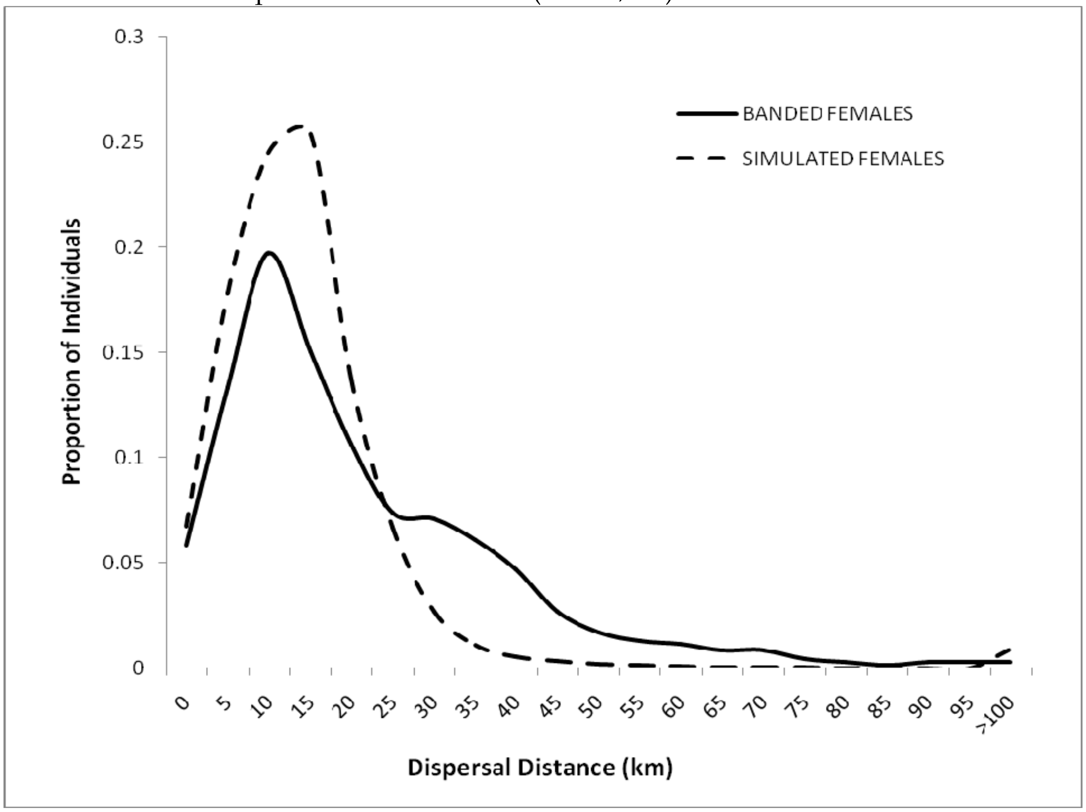
The Baseline HexSim simulations, in which barred owl impacts were introduced at time-step 40, then held static, produced an estimated total female spotted owl population size within the eight DSAs of 675. From field sampling, the total estimated female spotted owls in those DSAs based on the largest number recorded between 1996 and 2006 was 778. The average of the three highest density years from the annual reports (using only data from 1996-2006) for total estimated spotted owl females was 756. The mean of the highest three years (1996-2006) was selected instead of the highest single year in order to reduce the chance that a single year was uncharacteristic of the DSA (Figure C14). Differences in number of female spotted owls on the eight DSAs between those estimated from field sampling and those estimated from our HexSim runs ranged from 5% to 47%, with a mean absolute percentage difference of 26%. Subsequent changes to HexSim did not eliminate these differences.

**Figure C-14.** Model calibration: Comparison of simulated spotted owl population size (time step 50) to estimates based on field sampling in eight Demographic Study Areas.




Dispersal is a critical process through which landscape structure impacts spotted owl population size and meta-population structure, and is a primary concern in habitat conservation network design (Murphy and Noon 1992). Of particular importance is natal dispersal; the movements of juvenile spotted owls between their natal site and the site where they eventually establish breeding territories. We evaluated the performance of HexSim relative to natal dispersal by comparing graphs of simulated versus observed natal dispersal displacement distances (Figure C15). HexSim generates reports of annual dispersal events by non-territorial (juvenile and floater) spotted owls. The dispersal behavior of the simulated spotted owls was affected principally by landscape structure, the dispersal stopping criteria, and the amount of autocorrelation (both discussed above). Observed natal dispersal distances were estimated from movements of banded spotted owls (Forsman *et al.* 2002).

**Figure C-15.** Model calibration: Comparison of natal dispersal distances of banded female spotted owls (N= 328) from Forsman *et al.* (2002) to simulated natal dispersal distances for female spotted owls in HexSim (N=850,000).




Because our HexSim spotted owl scenario consists solely of females, we limited the comparison to banded female spotted owls. The distributions of natal dispersal distances for 328 banded female spotted owls were generally similar to 850,000 natal dispersal events recorded during a 250 time-step (years) HexSim simulation. The majority of both observed and simulated dispersal distances were between one and 25 km, however, about 10 % fewer simulated dispersal distances were greater than 10 km and 20% fewer were greater than 25 km.

## Uncertainties and Limitations

An important goal of the spatial population modeling effort is to provide a tool to evaluate and compare the suitability of suites of habitat conservation network scenarios. Each scenario represents a unique ensemble of conditions that could affect future spotted owl population size and trends. The overall amounts of spotted owl habitat, the arrangement of habitat conservation networks, and barred owl influences will vary from scenario to scenario.

Several conclusions about each scenario could be drawn from the HexSim spotted owl simulations. Very specific results, such as estimates of absolute population size, will be the most sensitive to parameter uncertainties. Less specific conclusions, such as the relative differences between scenarios, will be increasingly robust. The HexSim simulations provide, at a minimum, a

repeatable methodology for qualitatively ranking the efficacy of the habitat conservation scenarios. This analysis might also extend further, to include a quantification of individual reserve or block carrying capacities, and attendant probabilities of extinction. The conclusions that are drawn from a simulation model must balance concern over uncertainties with the desire to preserve a threatened species.

The HexSim spotted owl simulation model resulted from an attempt to construct the simplest model that could do a credible job of ranking habitat conservation network scenarios. HexSim makes adding realism relatively simple. But more life history detail does not automatically translate into more accurate forecasts. Realism comes at a cost since complex models have larger numbers of parameters, and thus greater data requirements.

There are many details that could be added to the existing HexSim simulation model. Examples include environmental stochasticity, the explicit modeling of spotted owl males (including mate-finding and pairing) and barred owl populations, genetics, disturbance regimes such as fire, etc. Some of these "enhancements" might provide more accurate forecasts of future spotted owl population sizes and probabilities of extinction, and decisions whether to incorporate some of them can be made in the future by model users depending on their specific needs. These enhancements, however, are not necessary in order to reliably rank habitat conservation network scenarios based on their likelihood of facilitating recovery of the spotted owl.

The modeling team considered several enhancements that could be added to the current HexSim spotted owl model. Some enhancements that might be made to the HexSim model are listed below.

## Environmental Stochasticity

Incorporation of environmental stochasticity into HexSim scenarios will be necessary when estimates of population size or extinction probability need to be made. However, the addition of environmental stochasticity is unlikely to change the order in which habitat conservation network scenarios rank (*i.e.*, from least to most likely to recover the spotted owl). Developing a modeling process to determine the rank-ordering of scenarios was the modeling team's primary goal, and environmental stochasticity was left out of these simulations in order to limit the computational burden associated with that analysis. Environmental stochasticity should be added to the HexSim model before it is used to estimate population sizes or extinction rates. At that time, the more variable model could be used to test a subset of the rank-ordering results obtained without environmental stochasticity. Recent research into the effects of variability in climate on spotted owl demographic rates (Glenn *et al.* 2010) suggested adding realistic variation in annual temperature and precipitation would provide an important element of environmental stochasticity into HexSim simulations.

**Effect of relative habitat suitability on reproductive rates**

The HexSim spotted owl model links habitat to survival rates through resource acquisition. Individual spotted owls acquire resources from their simulated home ranges, and home ranges with higher RHS values provide greater resources. But home ranges overlap, and competition between spotted owls will lower resource availability. Resource acquisition, because it links landscape structure and intra-specific competition, is a more realistic driver of survival rates than habitat would be on its own. Resource acquisition could easily influence reproduction in exactly the same way that it influences survival. Unfortunately, the most recent meta-analysis (Forsman *et al.* 2011) was inconclusive regarding the role that habitat played in determining reproductive rates. For this reason, the modeling team elected to not vary spotted owl reproductive rates as a function of resource acquisition.

**Effect of barred owls on reproductive rates**

The HexSim spotted owl model includes the machinery necessary for barred owl influences to include a lowering of spotted owl reproductive rates. This is done by setting a probability that a spotted owl in the presence of a barred owl will nest. Each year, every affected territorial spotted owl will make an independent nesting decision, based on this probability. However, in the current model, the probability that a spotted owl in the presence of a barred owl will forgo nesting entirely is set to zero.

Modeling team members determined that range-wide empirical estimates were not sufficient to assign region-by-region probabilities for barred owl impacts on spotted owl reproduction. Such impacts could come in several forms. For example, the presence of a barred owl could cause a spotted owl to abandon its territory, to keep the territory but forgo nesting (or calling for a mate), or a barred owl could lower effective spotted owl reproductive rates by interfering with nest-tending or preying on spotted owl offspring.

In order to simulate territory abandonment, it would be necessary to explicitly model barred owl locations across the landscape. But sufficient data on barred owl locations and habitat associations were not available range-wide to permit doing more than setting region-by-region probabilities of barred owl occurrence. Simulating barred owl predation on spotted owl offspring runs the risk of double-counting this impact, since barred owl presence does lower survival rates in the HexSim spotted owl model. As described above, the model is able to simulate a lowering of spotted owl nesting rates (when in the presence of a barred owl). But sufficient data was not available range-wide to do more than speculate on the associated parameter values.

**Interaction between habitat and barred owl effect**

By incorporating the barred owl into the spotted owl scenario as a dynamic spatially explicit stressor, the influence of habitat on barred owl presence and

barred owls effects to spotted owl occupancy (extinction rates), recruitment and survival could be more realistically simulated. While there is new information suggesting that habitat and barred owl effects may interact, the data necessary to develop reliable models of barred owl habitat suitability (and subsequently, distribution) are not available. For this reason, the modeling team elected not to attempt this. Moreover, outcomes of modeling region-specific simulations suggest that the current barred owl parameterization is realistic; low to intermediate barred owl encounter probabilities act to depress spotted owl populations but do not result in extinction.

**Sensitivity analyses**

When the HexSim spotted owl model is used to make estimates of population size, or probabilities of extinction, it will be necessary to also conduct a sensitivity analysis. The modeling team has conducted some work on a traditional sensitivity analysis. Whereas a traditional sensitivity analysis is focused on making small changes to individual parameter values, it would be instructive to complement this work with an assessment of the consequences of varying elements of the model structure itself. Examples of model design elements that might be varied include the lack of direct effects of resource acquisition on reproductive rates, the number of resource acquisition levels being simulated, and some of the behavioral features associated with dispersal and prospecting.

The most important parameters in any model of the spotted owl are going to be the survival and reproductive rates. The rates used in the HexSim survival and reproduction events have been derived from the most recent compendium of spotted owl field data (Forsman *et al.* 2011). Still, some uncertainty is introduced when these survival data are used to assign rates to spotted owls in three different resource acquisition classes, as that process involves extrapolation. We therefore elected not to use a larger number of resource acquisition classes. Likewise, the impact of barred owls on spotted owl reproduction is not perfectly understood, and certainly varies from region to region (as we represent in the HexSim scenarios).

One element of realism that the modeling team deemed necessary for this analysis was ensuring that the simulated spotted owls' home ranges and resource requirements varied by modeling region. The variation in home range size is supported by much published information (see review in Schilling 2009). The variation in resource requirements was used to account for regional differences in resource availability that were not captured in the MaxEnt resource map. In areas where the resource availability was known to be lower, spotted owls were assigned a higher resource requirement. The resource requirements were used as a fitting parameter that made it possible to adjust regional population sizes independently.

The HexSim spotted owl model described here is simple, but not overly so. It is likely the most realistic spatially-explicit individual-based spotted owl simulation that has been developed to-date. Its design and complexity mirror

what is being asked of it. Additional complexity may be added at a future time as needed to meet the goals that accompany other planning exercises.

**Testing Modeling Process Applications – Using the HexSim Spotted Owl Scenario model to compare the demographic effectiveness of various habitat conservation network scenarios and other recovery strategies:**

For the Revised Recovery Plan, the modeling team's objective was to develop and test a modeling framework (Steps 1-3) that would support a wide variety of recovery actions, including evaluation of habitat conservation network scenarios. To facilitate the implementation of recovery actions contained in the Revised Recovery Plan, the modeling team established a process for developing scenarios and conducted preliminary population simulations to compare a sample of habitat conservation network scenarios in order to test the modeling framework's reliability. The results from these preliminary comparisons were necessary in order to obtain feedback on the overall framework and provided the basis for revisions to the HexSim model. This objective was completed as part of the recovery planning process. The following evaluation consists of the actual comparison of simulated spotted owl population responses among many alternative scenarios representing various recovery strategies and habitat conservation networks.

## Development of Scenarios for Evaluation and Comparison in HexSim

An important use of the modeling framework is to simulate spotted owl population performance relative to three primary sources of variation: size (area) and distribution of habitat conservation networks; trends in habitat conditions inside and outside of the habitat conservation networks; and trends in the influence of barred owls. Considering the many possible variations in network designs, land ownership limitations, future habitat trends, and barred owl effects that could be evaluated, it is clear the number of scenarios needed to evaluate all of the possibilities could increase rapidly and become unfeasible. Instead, the modeling team developed an iterative process for evaluation of scenarios; establishing broad sideboards in earlier comparisons, then testing the models' sensitivity to habitat conditions and barred owl effects. The HexSim spotted owl model can also be used to evaluate the response of spotted owl populations to future climate scenarios.

To test the modeling framework's ability to evaluate the influence of habitat conservation network size (area) and spatial distribution on spotted owl population performance, we analyzed a subset of 10 habitat conservation network scenarios from Step 2 representing a wide range of sizes (proportions of "habitat value"), as well as existing habitat conservation networks (Table C28).

**Table C-28**. Initial set of habitat conservation networks evaluated in population modeling Rounds 1-3.

| Network **scenario** | **Code** |
|---|---|
| **Northwest Forest Plan Reserve Network** | **NWFP** |
| **Managed Owl Conservation Areas** | **MOCA** |
| **1992 Critical Habitat** | **1992CH** |
| **2008 Critical Habitat** | **2008CH** |
| **30% Zonation (All Lands Available)** | **Z30all** |
| **50% Zonation (All Lands Available)** | **Z50all** |
| **70% Zonation (All Lands Available)** | **Z70all** |
| **30% Zonation (Public Lands Only)** | **Z30pub** |
| **50% Zonation (Public Lands Only)** | **Z50pub** |
| **70% Zonation (Public Lands Only)** | **Z70pub** |

Maps depicting each of the network scenarios listed above are available at: http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/Recovery/Library/Default.aspx#Files
Once there, click on "maps" and "AppendixCMaps.pdf" The layers can be turned on and off using the "layers" button in the upper left-hand corner.

The habitat conservation networks listed in Table C28 form the basis for a series of comparisons in the population modeling environment (called Rounds) wherein different environmental conditions such as barred owl effects and habitat conditions are manipulated both spatially and temporally (scenarios). Each habitat conservation network that is subjected to different conditions is termed a habitat conservation network scenario. Rounds simply articulate the specific modifications that are made. The following paragraphs provide descriptions of the scenarios developed by the modeling team, and the results of HexSim runs for the scenarios in Rounds 1-3.

**Interpreting HexSim results:**

Each HexSim simulation run provides estimates of population size at any chosen time period as well as population trend over any range of time steps. Estimates are reported at both range-wide and regional scales. It is important to recognize that the results are intended to allow comparison of *relative population performance* among alternative habitat conservation network scenarios, not predictions of actual population size or trend in the future.

When a HexSim simulation starts, the number of individuals, age class distribution, spatial arrangement of territories, and other population attributes will have values that reflect the model's initial conditions. It takes many years for these artifacts to subside, and thus for the population's stable-state dynamics to become evident. Simulations were started with 10,000 female spotted owls, thus this initial period of transitory dynamics involved a period of rapid (apparent) population decline for the first 25 or 30 time-steps; typically subsiding by approximately time step 50. It is important not to confuse this decline with an observed or predicted loss in spotted owl numbers that has resulted from

changing environmental conditions. We could have chosen to begin simulations with many fewer spotted owls than are known to currently exist in the landscape (say 250), and waited many time-steps for them to increase and reach some sort of equilibrium with their simulated landscape. That would have resulted in a rapid (apparent) population *increase*, but again would simply be the transitory dynamics involved with the starting population conditions. The point is that the first 25-30 time steps are not meant to be interpreted, but can be thought of as a "burn-in" period for the simulation whereby the simulated spotted owls equilibrate with the simulated environment.

**Round 1: Baseline (2006) conditions**

This was the simple "Baseline" scenario that was used to evaluate parameterization of the HexSim spotted owl scenario. This scenario assumes no change in habitat through time (2006 RHS map); therefore the 10 habitat conservation networks listed above are not compared (because nothing different happens inside and outside of habitat blocks in this scenario). Also, barred owl effects remain constant over time (either at zero or constant at their currently-estimated impacts, beginning at time step 40).

Figures C16 through C18 highlight differences in the relative influence of barred owls among modeling regions. Rangewide, barred owls act to depress spotted owl populations to roughly 50 percent of potential population size without barred owls (Figure C16). However, spotted owl populations in modeling regions with high barred owl encounter rates such as the Oregon Coast Ranges ($P_{BO}$ = 0.710; figure C17) decline rapidly in comparison to modeling regions with low to intermediate barred owl encounter rates such as the Western Klamath ($P_{BO}$ = 0.315; figure C18).

**Figure C-16**. Results of HexSim Round 1 model runs with five replicates each for "Without STVA" (barred owl) impacts and "With STVA" impacts for the spotted owl's entire geographic range in the U.S. The apparent within-year variation that appears in the figure is a function of an "even-odd" year effect on reproduction that was included in this version of the HexSim model.

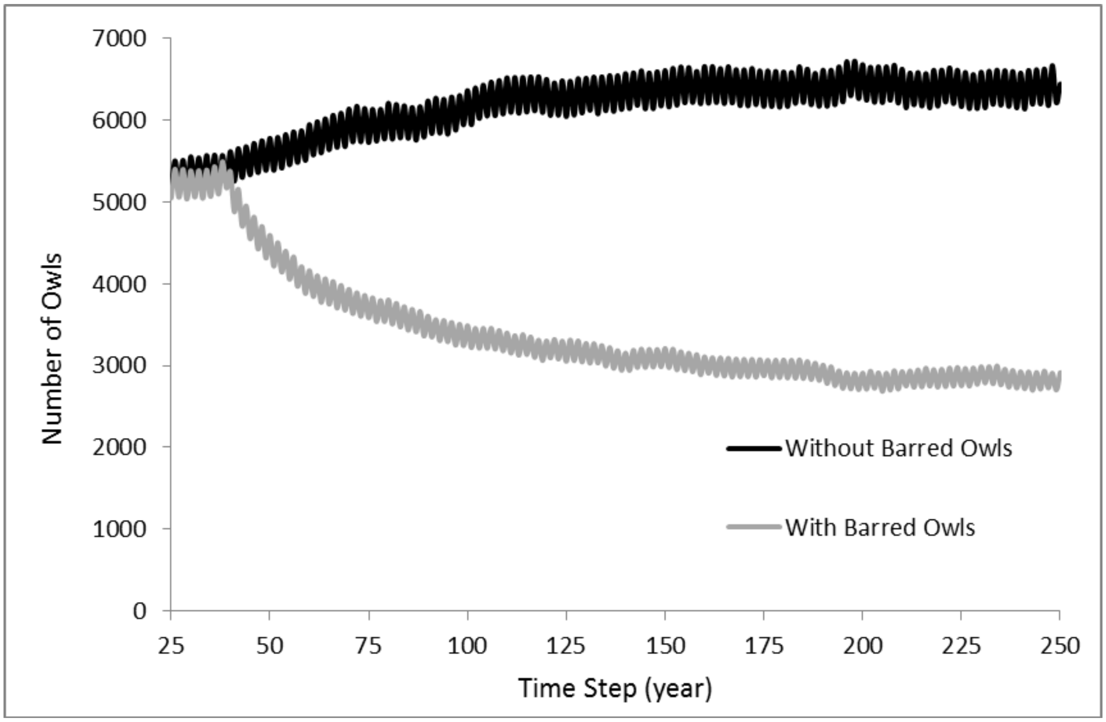



**Figure C-17**. Simulated Round 1 spotted owl population sizes in the Oregon Coast Ranges modeling region showing 1) current barred owl influence and 2) barred owl influence removed.

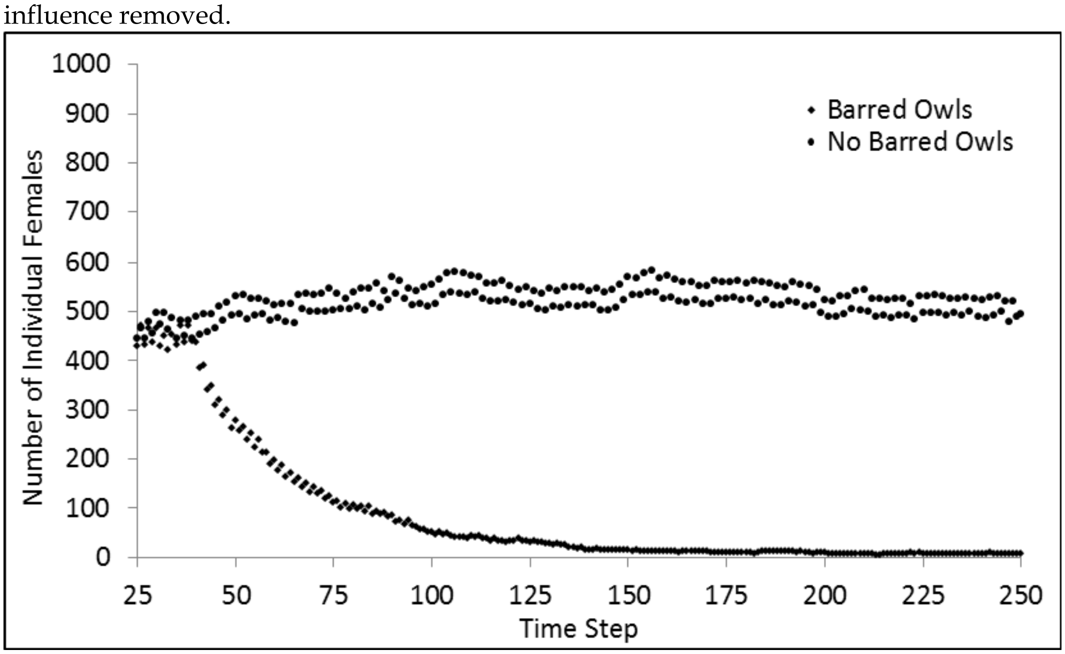
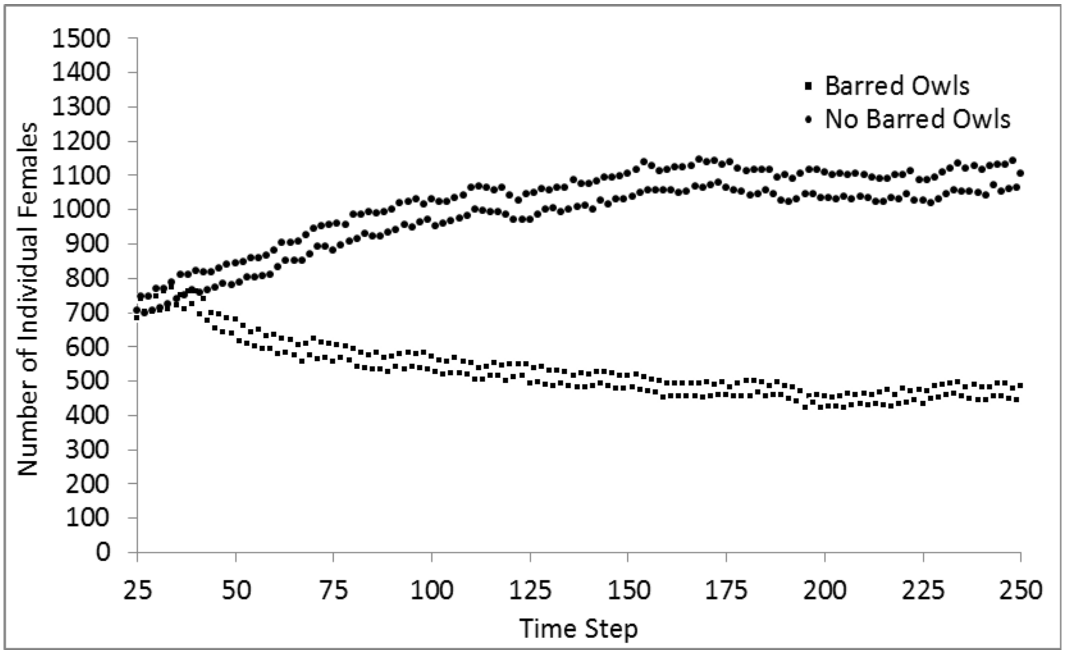


**Figure C-18**. Simulated Round 1 spotted owl population sizes in the Western Klamath modeling region showing 1) current barred owl influence, and 2) barred owl influence removed.




**Round 2: Simulating a high degree of reliance on habitat conservation networks**

Because the primary objective in this evaluation is to compare estimated spotted owl population performance across a range of habitat conservation network, the goal of Round 2 was to "isolate" the habitat conservation networks by devaluing non-network habitat suitability and holding habitat in networks at its 2006 estimated level throughout the simulation. In this scenario, we reduced relative habitat suitability (RHS) *outside* of habitat conservation networks to 34 (RHS=0.34); *just below* that needed for territory establishment; RHS within networks remained unchanged. The influence of barred owls was held to the currently-estimated encounter rates calculated from Forsman *et al.* (2011); the barred owl influence was slotted in at year 40. We repeated Round 2 with *No barred owl effect*, to evaluate the relative contribution of habitat and barred owl effects on simulated spotted owl population performance. The results of the Round 2 simulations allow for an evaluation of the relative influence of habitat conservation network size and distribution (relying primarily on public versus both public and private lands) and barred owls on spotted owl population performance – when the habitat conservation network provides nearly all nesting and roosting habitat.

## Round 3: Simulating RA10 - retention of high-value habitat outside of habitat blocks

The goal of Round 3 was to evaluate the relative contribution of habitat conditions ***outside*** of habitat conservation networks to spotted owl populations; Scenarios R3S1 through R3S10 are intended to emulate the management approach of maintaining occupied spotted owl territories outside of network areas . RHS within habitat conservation networks was held constant, and areas of high RHS (>50) *outside* of networks (on public lands) were retained through time. Areas of RHS between 35 and 49 (outside of networks) were decremented to RHS 34. Scenarios R3S11 through R3S20 were similar but apply to *all* non-network lands (public and private). We repeated Round 3 with *No barred owl effect*, to evaluate the relative contribution of habitat and barred owl effects on simulated spotted owl population performance.

Figures C19 and C20 provide examples of different metrics that can be used to compare estimated spotted owl population outcomes among habitat conservation network scenarios, in this case Rounds 2 and 3 described above. Initial results using a wide range of population metrics can provide insights for meeting the recovery criteria established in the Revised Recovery Plan. Comparison of these estimates of spotted owl population performance across the range of scenarios can inform evaluation of habitat conservation networks designed to lead to spotted owl recovery.

Figure C19 provides results for the entire range of the spotted owl, but as described in Round 1 and evidenced in Figure C20, it is important to recognize that population outcomes may differ markedly among modeling regions.

**Figure C-19**. Comparison of percent population change (rangewide) between year 25 and year 250 under the scenarios in Rounds 2 and 3, with and without barred owl influence. MOCAs and critical habitat were not compared for Round 3.

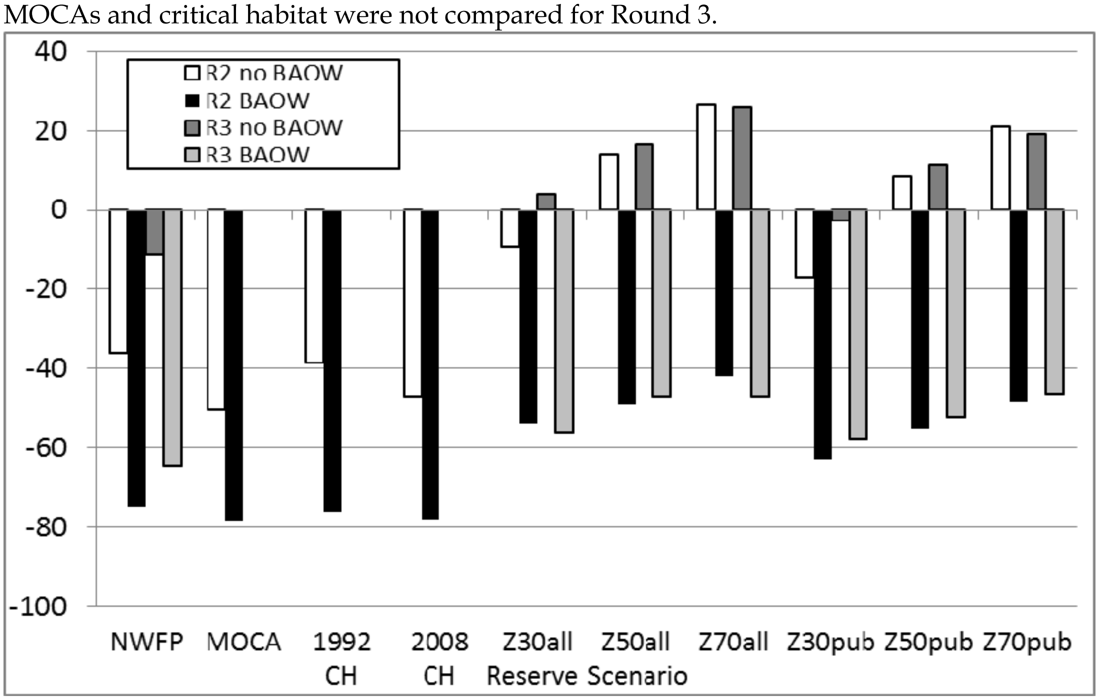
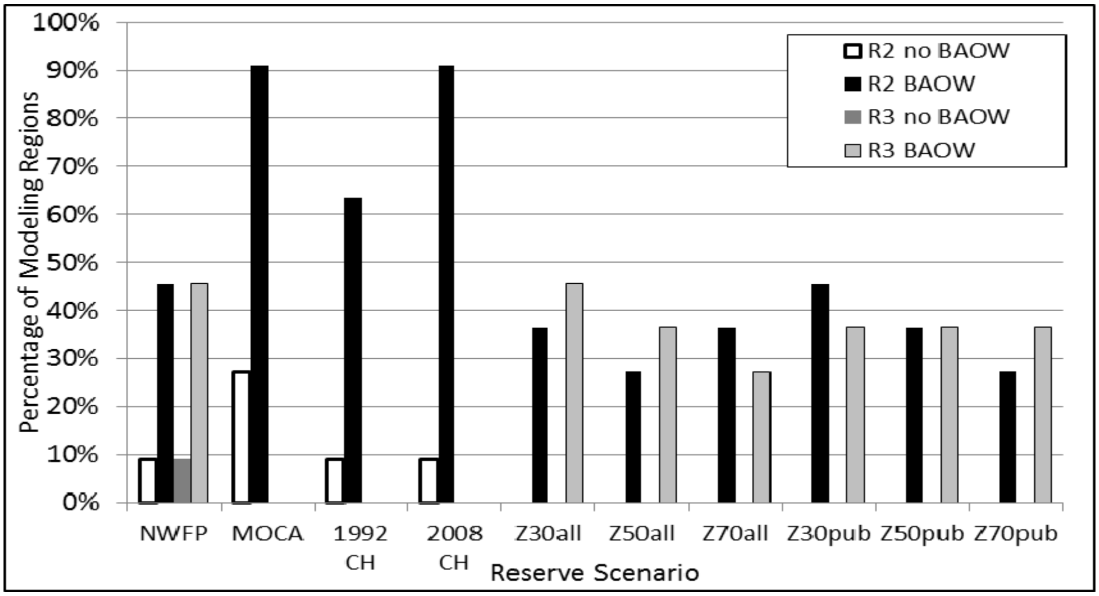


**Figure C-20**. Percentage of modeling regions whose simulated populations declined by more than 75% between years 25 and 250 (indication of extinction risk) under the scenarios in Rounds 2 and 3, with and without barred owl influence.




The interaction of network size with other conservation measures is highlighted in Figures C19 and C20. In Round 3 (simulated RA10 - retention of likely occupied, high-value habitat with RHS>50 in non-network areas), the amount of habitat "retained" is inversely proportional to the size of area within habitat conservation networks Subsequently, RA 10's benefit to simulated spotted owl populations is relatively less for larger habitat conservation network scenarios such as Z50 and Z70.

**Conclusions:**

The analysis presented in this appendix is intended to demonstrate how the three-part modeling framework can be used to evaluate spotted owl population response to a variety of environmental conditions such as habitat variation and barred owls. Although this initial analysis is intended to evaluate the modeling framework, it provides insight into factors influencing spotted owl populations and conservation planning for recovery of the spotted owl.

HexSim population simulations can be completed for the entire range of the spotted owl as well as for subsets of the species' range, such as individual modeling regions or DSAs. This capability enables evaluation of varying environmental conditions and subsequent population effects occurring in different parts of the species' range. For example, the relative effect of barred owls on spotted owl survival and subsequent population size varies among modeling regions, in accordance with different barred owl encounter rates (Table C29). Comparison of the relative differences between simulated spotted owl populations without barred owls and those resulting from different barred owl encounter rates among modeling regions (Figures C17 and C18) suggests there

may be barred owl population levels (encounter rates) below which spotted owl populations remain stable (albeit at lower population sizes). Further evaluation of these relationships may inform planning of barred owl management scenarios.

**Table C-29.** Barred owl encounter probabilities estimated from Forsman *et al.* (2011).

| Region | Encounter Probability |
|---|---|
| North Coast Olympics | 0.505 |
| East Cascades North | 0.296 |
| West Cascades North | 0.320 |
| West Cascades Central | 0.320 |
| Oregon Coast | 0.710 |
| West Cascades South | 0.364 |
| Inner CA Coast Range | 0.213 |
| East Cascades South | 0.180 |
| Klamath East | 0.245 |
| Klamath West | 0.315 |
| Redwood Coast | 0.205 |

As shown in Figure C1, the modeling framework contains feedback loops that facilitate an iterative process, with each iteration informed by the results of previous scenarios and simulated population outcomes. This process enables an adaptive approach to developing and testing conservation measures. As new information from monitoring or other research becomes available, its influence on spotted owl conservation can be incorporated into subsequent evaluations in a consistent manner.

In sum, our goal was to develop a modeling framework that can be applied by interested parties to make better informed decisions concerning spotted owl management and recovery. The analyses described in this appendix represent a small subset of possible scenarios and are presented to test the framework and to give potential users of this approach some preliminary exposure to the models' potential utility. Future conservation planning for spotted owls will require development and evaluation of additional scenarios that are relevant to the management questions of particular interest to various stakeholders. These future planning efforts will likely address temporal factors such as changing barred owl populations, climate change, and future habitat change. They might also apply to private land managers who are evaluating different options within a Habitat Conservation Planning scenario, or Federal land managers who are considering recommendations for amending long-term forest management plans. Whatever the use to which this framework is applied, our goal was to provide managers with tools that will ultimately result in better informed decisions for spotted owl conservation.

# Appendix D. References Cited

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# Appendix E. Comments and Responses to Comments on the Draft Revised Recovery Plan

A complete list of the comments on the draft Revised Recovery Plan and the responses to those comments can be found at the following web site:

http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/Recovery/Plan/

# Appendix F. Scientific Names for Common Names Used in the Text

Following is a list of scientific names for common names of plants and animals used in the text.

**Trees**

| | |
|---|---|
| White fir | *Abies concolor* |
| Grand fir | *Abies grandis* |
| Shasta red fir | *Abies magnifica shastensis* |
| Western larch | *Larix occidentalis* |
| Tanoak | *Lithocarpus densiflorus* |
| Pinyon pine | *Pinus edulis* |
| Ponderosa pine | *Pinus ponderosa* |
| Sugar pine | *Pinus lambertiana* |
| Bishop pine | *Pinus muricata* |
| Lodgepole pine | *Pinus contorta* |
| Douglas-fir | *Pseudotsuga menziesii* |
| Coast redwood | *Sequoia sempervirens* |
| Western redcedar | *Thuja plicata* |
| Western hemlock | *Tsuga heterophylla* |
| Mountain hemlock | *Tsuga mertensiana* |

**Mammals**

| | |
|---|---|
| Tree voles | *Arborimus longicaudus, A. pomo* |
| Red-backed voles | *Clethrionomys* spp. |
| Northern flying squirrel | *Glaucomys sabrinus* |
| Snowshoe hare | *Lepus americanus* |
| Dusky-footed wood rat | *Neotoma fuscipes* |
| Bushy-tailed wood rat | *Neotoma cinerea* |
| Gophers | *Thomomys* spp. |

**Birds**

| | |
|---|---|
| Northern goshawk | *Accipiter gentilis* |
| Red-tailed hawk | *Buteo jamaicensis* |
| Great horned owl | *Bubo virginianus* |
| Eastern screech-owl | *Otus asio* |
| Northern spotted owl | *Strix occidentalis caurina* |
| California spotted owl | *Strix occidentalis occidentalis* |
| Mexican spotted owl | *Strix occidentalis lucida* |
| Barred owl | *Strix varia* |

**Other species**

| | |
|---|---|
| Bark beetle | *Dendroctonus* spp. |
| Mountain pine beetle | *Dendroctonus ponderosae* |

| | |
|---|---|
| Spruce beetle | *Dendroctonus rufipennis* |
| Western spruce budworm | *Choristoneura occidentalis* |
| West Nile virus | *Flavivirus* |
| Avian influenza | *Orthomyxoviridae* |
| Swiss needle cast | *Phaeocryptopus gaeumannii* |
| Sudden oak death | *Phytopthora ramorum* |
| Avian malaria | *Plasmodium* spp. |
| Truffles | *Tuber* spp. |

# Appendix G. Glossary of Terms

Many of these terms have a long history and various meanings in regard to spotted owl biology and management. This glossary defines the context in which they are used in this document.

**Activity Center**: Spotted owls have been characterized as central-place foragers, where individuals forage over a wide area and subsequently return to a nest or roost location that is often centrally-located within the home range (Rosenberg and McKelvey 1999). Activity centers are location or point within the core use area that represent this central location. Nest sites are typically used to identify activity centers, or in cases where nests have not been identified, breeding season roost sites or areas of concentrated nighttime detections may be used to identify activity centers.

**Adaptive Management:** Adaptive management is a systematic approach for improving resource management by learning from the results of explicit management policies and practices and applying that learning to future management decisions.

**Conserve:** To preserve to use, or manage wisely.

**Core Use Area:** An area of concentrated use within a home range that receives disproportionally high use (Bingham and Noon 1993), and commonly includes nest sites, roost sites, and foraging areas close to the activity center. Core use areas vary geographically, and in relation to habitat conditions. This is a biological definition of core use area and is not the same as a 70-acre core as defined by the Oregon Forest Practices Act nor is it equivalent to the 100-acre LSRs referred to as northern spotted owl cores on Federal lands.

**Dispersal Habitat**: Juvenile spotted owls often must disperse through a range of forest types prior to finding NRF habitat on which to establish a territory. These forest types include nesting, roosting, and foraging habitat in addition to forest that meets the definition of dispersal habitat. The Interagency Scientific Committee (ISC) defined dispersal habitat as forest stands with average tree diameters ≥11 inches and conifer overstory trees with closed canopies (>40 percent canopy closure in moist forests and >30 in dry forests) and with open space beneath the canopy to allow spotted owls to fly can provide the minimum conditions needed for successful dispersal (Thomas *et al.* 1990:310). We acknowledge that this definition primarily applies to moist forests in Oregon and Washington and may not capture the full range of dispersal habitat conditions in Northern California or drier forests across the range of the spotted owl.

**Early-seral Forest:** Stage of forest development that includes seedling, sapling, and pole-sized trees.

**Foraging Habitat:** Foraging habitat is defined as lands that provide foraging opportunities for spotted owls, but without the structure to support nesting and roosting (USFWS 1992b). Spotted owls often forage in forest conditions that meet the definition of nesting/roosting habitat, but also use a broader range of forest types for foraging. This definition identifies habitat that functions as foraging habitat, but does not meet requirements for nesting or roosting.

**Habitat-capable Area:** Forests below the elevation limits of occupancy by territorial spotted owls that are capable of growing and sustaining structural (Davis and Lint 2005) and ecological conditions of spotted owl habitat.

**High-Quality Habitat**: Older, multi-layered structurally complex forests that are characterized as having large diameter trees, high amounts of canopy cover, and decadence components such as broken-topped live trees, mistletoe, cavities, large snags, and fallen trees. This is a subset of spotted owl habitat and specific characteristics may vary due to climatic gradients and abiotic factors across the range.

**High-Value Habitat:** Habitat that is important for maintaining spotted owls on landscapes. Includes areas meeting definition of high-quality habitat, but also areas with current and historic use by spotted owls that may not meet the definition of high-quality habitat.

**Historical Site:** Sites that contained spotted owls in the past. These may be currently unoccupied or sites where spotted owls were detected in the past, but not surveyed more recently.

**Home Range:** The area in which a spotted owl conducts its activities during a defined period of time (USFWS 1992b) that provides important habitat elements for nesting, roosting, and foraging. Home range sizes vary generally increase from south to north and vary in relation to habitat conditions and prey availability and composition.

**Known Spotted Owl Site:** An occupied spotted owl site or a spotted owl site where spotted owls were documented to be present in the past.

**Late-seral Forest:** Stage in forest development that includes mature and old-growth forest (USDA *et al.* 1993). The appearance and structure of these forests will vary across the range of the spotted owl, particularly in the dry forest provinces.

**Long-term**: For the purposes of planning and managing the spotted owl and its forest habitat, a time frame estimated to be greater than 30 years at a minimum and usually referring to time periods ranging from 50 years to several centuries. Use of this term can be context dependent and relative, for example, when referring to gradual demographic changes in a spotted owl population or the development of late-successional habitat conditions.

**Manage**: To make and act upon decisions about which actions to take, if any, regarding a particular issue, area of land, etc. This may include a decision to take no action.

**Mature Forest:** Forests where the annual net rate of growth has peaked. Stand age, diameter of dominant trees, and stand structure at maturity vary by forest types and local site conditions. Mature stands generally contain trees with a smaller average diameter, less age-class variation and less structural complexity than old growth stands of the same forest type (USDA *et al.* 1993). The appearance and structure of these forests will vary across the range of the spotted owl, particularly in the dry forest provinces. Mature stages of some forests provide NRF habitat for spotted owls. However, mature forests are not always spotted owl habitat, and spotted owl habitat is not always mature forest.

**Mid-seral Forest:** Intermediate stages of tree growth between early-seral and late-seral. The appearance and structure of these forests will vary across the range of the spotted owl, particularly in the dry forest provinces.

**Nesting and Roosting Habitat:** Habitat that provides nesting and roosting opportunities for spotted owls. Important stand elements may include high canopy closure, a multi-layered, multi-species canopy with larger overstory trees and a presence of broken-topped trees or other nesting platforms (*e.g.,* mistletoe clumps (USFWS 1992b). The appearance and structure of these forests will vary across the range of the spotted owl, particularly in the dry forest provinces.

**Occupied Site:** Any location where territorial spotted owls are known to be present.

**Old-growth Forest:** Old-growth forests are forests that have accumulated specific characteristics related to tree size, canopy structure, snags and woody debris and plant associations. Ecological characteristics of old-growth forests emerge through the processes of succession. Certain features - presence of large, old trees, multilayered canopies, forest gaps, snags, woody debris, and a particular set of species that occur primarily in old-growth forests - do not appear simultaneously, nor at a fixed time in stand development. Old-growth forests support assemblages of plants and animals, environmental conditions, and ecological processes that are not found in younger forests (younger than 150-250 years) or in small patches of large, old trees. Specific attributes of old-growth forests develop through forest succession until the collective properties of an older forest are evident.

**Protect**: Guard or shield from loss.

**Provincial:** This is a qualifying term used with home range and core use area to reflect the fact that both vary in size according to latitude, amount of available

habitat, prey availability, and forest structure and composition. Typically, home range and core use area sizes increase from south to north, and decrease as amount of high-quality habitat available to spotted owls increases.

**Restoration:** The recovery of vegetative structure, species composition, and self-regulating ecological processes at multiple spatial and temporal scales with the intent to provide for long-term ecological sustainability and ecological integrity.

**Resilience:** Resilience refers to the capacity of an ecosystem to not only accommodate gradual changes but to return toward a prior condition after disturbances including fire, extreme weather events, and climate change.

**Retain:** To keep.

**Short-term:** For the purposes of planning and managing the spotted owl and its forest habitat, a time frame estimated to be less than a few decades and usually between one to ten years. Use of this term can be context dependent and relative, for example, when referring to immediate changes in a forest stand due to a wildfire or vegetation treatment, or the behavioral response of individual spotted owls to habitat alteration or the removal of barred owls from a spotted owl territory.

**Snag:** Any standing dead or partially dead tree. A hard snag is composed primarily of sound (merchantable) wood while a soft snag is composed of wood in advanced stages of decay and deterioration, and is not generally merchantable.

**Spotted Owl Site:** Any location where territorial spotted owls are known to be present, were historically present, or may be present in unsurveyed habitat. Spotted owl sites can be identified through surveys where spotted owls were detected (USFWS 2010). In cases where survey data are unavailable, spotted owl sites can be identified by 1) conducting surveys, or 2) using a modeling approach that uses habitat and landscape characteristics to identify areas with a high probability of being occupied by spotted owls.

**Uncharacteristic Wildfire** – Fires that threaten the loss of key ecological attributes and functions, due primarily to the diminishment of natural landscape resilience mechanisms.

**Unoccupied Site:** Site where spotted owls were detected in the past, but more recent surveys have not detected owls. Surveys are required to establish unoccupied status, and criteria for determining unoccupied status are presented in the 2010 (2011) Northern Spotted Owl Survey Protocol (USFWS 2011).

**Viable Population** - a self-sustaining population with a high probability of survival despite the foreseeable effects of demographic, environmental and genetic stochasticity and of natural catastrophes.

# Appendix H. Contributors To The 2008 Recovery Plan

A Recovery Plan for the Northern Spotted Owl (2008 Recovery Plan) was prepared with the assistance of a Recovery Team representing Federal agencies, State governments, and other affected and interested parties, as well as the assistance of a contractor (Sustainable Ecosystems Institute or SEI) and published May 14, 2008. The Recovery Team members served as independent advisors to the Service for the development of the 2007 Draft Recovery Plan. The 2008 Recovery Plan did not necessarily represent the view or official position of any individual or organization—other than that of the Service—involved in its development. Additional valuable support was provided by three work groups of Federal and State agency scientists and academic researchers.

The Service gratefully acknowledges the effort and commitment of the many individuals involved in the conservation and recovery of the northern spotted owl who participated in the preparation of the 2008 Recovery Plan. Without their individual expertise and support, this Revised Recovery Plan would not have been possible as it is the culmination of many years of labor.

The Service began preparing a recovery plan for the spotted owl in April 2006. To advise the Service, a Recovery Team was initially appointed which was supported by an Interagency Support Team (IST) and led by a Recovery Plan Project Manager. During the development of the 2007 Draft Recovery Plan, the Recovery Team convened several panels of experts to advise them and provide information on scientific and land management issues (noted as Scientist and Implementer Panelists below). The Service is indebted to all of the individuals for the guidance provided during the preparation of the 2007 Draft Plan. Their names, affiliations, and roles are listed below.

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The 2007 Draft Recovery Plan generated more than 75,800 public comments. To evaluate scientific and management issues highlighted during the comment period, the Service contracted with an independent consultant (SEI) to provide assistance. In addition, the Service appointed three scientific work groups to evaluate comments and provide guidance on the best science concerning the three major areas of concern raised during the comment period: spotted owl habitat, fire, and barred owls. Based on this input, and comments from the public, the Service finalized the 2008 Recovery Plan. We thank all of these individuals; they are listed below.

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# EXHIBIT D

Pages 815-827 in McCullough, D. R. and R. H. Barrett, eds.
Wildlife 2001: Populations. Elsevier Applied Science,
London, England. 1163 pp. (1992)

# POPULATION REGULATION IN NORTHERN SPOTTED OWLS: THEORETICAL IMPLICATIONS FOR MANAGEMENT

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*Abstract.* A marked population of northern spotted owls was examined within a bounded, 292-km² study area in northwestern California over a six-year period (1985-1990). Observed and predicted finite rates of population change ($\hat{\lambda}$) for male spotted owls were significantly stable. Predicted $\hat{\lambda}$ for females indicated a significant decline even though observed $\hat{\lambda}$ indicated stability. Observed stability in numbers of territorial males was maintained by recruitment, whereas stability in numbers of females was maintained by immigration. Most recruits did not become territory holders until several years after their birth. I hypothesized that the study area population was regulated by territorial behavior. Under this mechanism, spotted owl populations may be declining even though observed numbers of territorial birds appear to be stable. Using a computer model, I examined the effects of "floaters" on the stability of territory holders, and suggest warning signals which may predict imminent instability for the population.

## INTRODUCTION

The northern spotted owl (*Strix occidentalis caurina*) is a non-migratory, medium-sized owl that inhabits coniferous forests of the Pacific Northwest (Forsman et al. 1984, Gutiérrez and Carey 1985). Pairs of northern spotted owls occupy large home ranges (≥ 3500 ha) portions of which they actively defend against conspecifics (Forsman 1980). However, adjacent spotted owl territories may be separated by broad areas of overlap rather than distinct boundaries because of their large home ranges (Forsman 1980). In addition, this species exhibits strong site tenacity, and individuals probably occupy the same territories for life (Forsman et al. 1984). Although splitting of pairs and movements of occupants between territories do occur, they are relatively infrequent (Franklin et al. 1990*a*).

Northern spotted owls exhibit a strong affinity for old-growth forests (reviewed in Anderson et al. 1990) and may incorporate large tracts (≥ 400 ha) of these forests into their home ranges (Forsman et al. 1984, Solis and Gutiérrez 1990, Carey et al. 1990). Thus, a conflict has developed concerning management of spotted owl populations because of the high economic value associated with old-growth forests (Simberloff 1987).

This conflict was further polarized when the northern spotted owl was Federally listed as a threatened subspecies (U. S. Fish and Wildlife Service 1990).

Through the use of life-table and matrix models, Marcot and Holthausen (1987), Lande (1988), and Noon and Biles (1990) predicted that spotted owl populations were declining by 3.9 - 16.0% a year, although in some cases these declines were not statistically different from stable. Over a 4-year period, Franklin et al. (1990*b*) observed a slight increase, or at least stability, in a marked population of spotted owls in northwest California, even though demographic parameters collected from this study predicted a statistically significant decline in females (Anderson et al. 1990). The discrepancy between predicted and observed population trends led to the hypothesis that northern spotted owl populations are regulated by territorial behavior (Franklin and Gutiérrez 1987) with a floating, non-territorial component which is overlooked, and a territorial component which is measured in population censuses.

Among others, Howard (1920) and Nice (1941) hypothesized that, in avian populations, some individuals excluded from territories form a reserve supply to regulate breeding densities by replacing territorial individuals who die. This hypothesis was extended by Brown (1969) who proposed a model classifying three critical levels at which territoriality affects dispersion patterns of individuals. At level 1, density is sufficiently low that no individual is prevented from breeding in favorable habitats: individuals are dispersed non-randomly because of territorial behavior. At level 2, rich habitats are saturated with territorial individuals; individuals prevented from settling there breed in less favorable habitats. And, at level 3, all habitats which support breeding individuals are saturated, and a surplus of non-breeding, non-territorial floaters exists. In many studies of avian populations, it was concluded that territorial behavior regulates the number of individuals holding territories and having the immediate potential for breeding (see reviews in Brown 1969, Klomp 1972, Patterson 1980, Smith and Arcese 1986, Sinclair 1989). Wilcove and Terborgh (1984) predicted that a decline in populations regulated by territorial behavior would occur first in the floating component. Declines in the territorial component initially would be dampened by increased recruitment of floaters. If the number of floaters is sizeable, then the number of territory holders would appear stable for some time before a decline is observed.

In this paper, I examine the hypothesis that territorial behavior regulates the size of spotted owl populations by examining observed and predicted population trends, and recruitment and immigration in a bounded, marked population. I also attempt to quantify how such a regulatory mechanism may influence potential declines in spotted owl populations, and the implication for management of this species.

## METHODS

Spotted owls were studied from 1985 through 1990 in two areas of northwest California: a regional study area (RSA) encompassing about 10 000 km$^2$ and the Willow Creek Study Area (WCSA) encompassing 292 km$^2$ (Franklin et al. 1990*a*,*b*). The WCSA was bounded by major topographic features to minimize spotted owl territories overlapping the edge of the area. The WCSA was completely surveyed each year for the



presence of spotted owls (Franklin et al. 1990*a*,*b*). The WCSA contained 47 spotted owl territories, not all of which were occupied each year. The RSA surrounding the WCSA contained an additional 41 territories distributed in clusters of 2 to 5 territories. Complete descriptions of the WCSA and RSA can be found in Franklin et al. (1990*a*,*b*).

Spotted owl populations were surveyed by using imitated calls to elicit vocal response from territory holders (Forsman 1983, Franklin et al. 1990*a*,*b*). Spotted owls were surveyed at night to determine presence of individuals in an area, and during the day to locate roosts and nests and to mark individuals (Forsman 1983, Franklin et al. 1990*a*). Owls were sexed according to Forsman (1983). Reproductive status was determined for all individuals using methods outlined in Forsman (1983) and Franklin et al. (*in preparation*). Young were counted after fledging. Once located, individuals were placed into 4 age classes according to criteria in Moen et al. (1990): J - juveniles or young of the year (age, $x = 0$ years); S1 - 1st-year subadult ($x = 1$); S2 - 2nd-year subadult ($x = 2$); and A - adults ($x \geq 3$). All owls located were banded with U. S. Fish and Wildlife Service leg bands. Subadults and adults were also individually color-banded, which allowed visual identification of individuals in subsequent years (Franklin et al. 1990*b*).

The entire WCSA was systematically surveyed for spotted owls between 1 April and 30 August each year from 1985 through 1990. I estimated the number ($\hat{N}_t$) of adult and subadult owls at year $t$ using empirical methods (Franklin et al. 1990*b*) and Jolly-Seber capture-recapture estimates with program JOLLY (Pollock et al. 1990). The use of Jolly-Seber estimates with spotted owl capture-recapture data from the WCSA was examined in detail by (Franklin et al. 1990*b*). The finite rate of increase ($\hat{\lambda}$) for observed numbers on the WCSA was calculated as the ratio of numbers in 2 successive years (Caughley 1977:51):

$$\hat{\lambda}_i = \frac{\hat{N}_{t+1}}{\hat{N}_t} . \qquad (1)$$

An arithmetic mean and standard error for $\hat{\lambda}_i$ for the 6-year period was calculated to obtain observed estimates of $\hat{\lambda}$.

I used a 4 age-class modified Leslie matrix (Leslie 1945, Usher 1972, Cullen 1985:63-66) to compute predicted estimates of $\hat{\lambda}$, based solely on age-specific fecundities and survival probabilities estimated for male and female spotted owls on the WCSA between 1985 through 1990. The form of the matrix followed Usher (1972) and Cullen (1985:50,64):

$$\begin{vmatrix} \phi_0 m_1 & \phi_1 m_2 & \phi_2 m_3 & \phi_3 m_3 \\ \phi_0 & 0 & 0 & 0 \\ 0 & \phi_1 & 0 & 0 \\ 0 & 0 & \phi_2 & \phi_3 \end{vmatrix} \qquad (2)$$

where $\phi_x$ (for $x = 0...3$) is the probability that an individual in age-class x survives to age $x$+1 and $m_x$ is the average number of female (or male) fledglings produced by a female (or male) of age $x$. This form of the matrix assumed a birth-pulse population with a postbreeding census and a projection interval of one year (Cullen 1985:50). Rationales for this approach are explained in Anderson et al. (1990) and Thomas et al. (1989). The dominant eigenvalue of (2), representing the finite rate of population change ($\hat{\lambda}$), and it's associated (right) eigenvector, representing the stable age-class distribution, were

calculated by eigenanalysis of (2) using the power method (Cullen 1985:37-42, Caswell 1989:79). Variance of $\hat{\lambda}$ was approximated using the delta method (Caswell 1989:185, Seber 1982:7-9):

$$\sum_{i,j}\left(\frac{\delta\hat{\lambda}}{\delta x_{ij}}\right)^2 V(x_{ij}) + 2\sum_{ij<}\sum_{kl} cov[x_{ij}, x_{kl}]\left(\frac{\delta\hat{\lambda}}{\delta x_{ij}}\right)\left(\frac{\delta\hat{\lambda}}{\delta x_{kl}}\right) \text{ where } \frac{\delta\hat{\lambda}}{\delta x_{ij}} = \frac{v_i w_j}{\langle w, v\rangle}, \quad (3)$$

where $x_{ij}$ represented the non-zero matrix elements, $V(x_{ij})$ their sampling variances, $v_i$ and $w_j$ the corresponding elements of the left ($v$) and right ($w$) eigenvectors of (2) and $\langle w,v \rangle$ the scalar product of $w$ and $v$ (Caswell 1989:119-121). Only covariances for survival rates were estimated and included in (3).

The strategy in calculating parameters for the matrix model was to reduce the number of estimates required to increase precision for each parameter. In estimating $\hat{\phi}_x$ and $\hat{m}_x$ for spotted owls on the WCSA, I assumed there was a 1:1 sex ratio at fledging and $\hat{m}_x$ for males could be calculated in a manner similar to females since spotted owls were monogamous and males provided an equivalent amount of care for young (Forsman et al. 1984). Maximum likelihood estimates (MLE) of $\hat{\phi}_x$ for J, S1, S2, and A age-classes were calculated using the approach of Anderson et al. (1990) and Le Breton et al. (*in press*) summarized as follows: (1) MLE were estimated using program SURGE (Clobert et al. 1987) for each sex starting with a four age-class model ($\hat{\phi}_x$, $\hat{p}_x$) which was incrementally reduced to a two age-class model ($\hat{\phi}_0$, $\hat{\phi}_{1\text{-}3}$, $\hat{p}$). (2) Akaike Information Criterion (AIC) (Akaike 1973) was used to objectively select the most appropriate model. (3) neighboring models were tested against each other using likelihood ratio tests to further examine model fit. And, (4) an overall goodness-of-fit test was calculated for the most reduced parameter model ($\hat{\phi}_0$, $\hat{\phi}_{1\text{-}3}$, $\hat{p}$) using programs JOLLYAGE (Pollock et al. 1990) and RELEASE (Burnham et al. 1987). Capture histories for individuals captured as juveniles were adjusted to reflect a 1:1 sex ratio at birth because I was unable to sex juveniles. For each years cohort of banded juveniles, the individuals subsequently recaptured were sexed and the remaining capture histories (representing individuals never recaptured) were arbitrarily assigned as males or females so that the total number of males and females was equal.

Age-specific estimates of $\hat{m}_x$ for males and females were calculated as the mean number of young fledged from individuals in the S1, S2 and A age-classes. Juveniles did not breed. Values of $\hat{m}_x$ were calculated by halving the number of young fledged by each individual prior to calculating means and variances to represent a 1:1 sex ratio. Estimates of $\hat{m}_x$ for each sex were tested using one-way analysis of variance (Zar 1984:163-170) and non-significant subsets were pooled. After Seber (1982:3-4), I measured recruitment as the number of juveniles born on the WCSA which were later recaptured in the WCSA as territorial birds, and immigration as the number of new, unbanded subadults and adults encountered as territorial birds after 1985. New territory holders (NTH) were assumed to be the sum of recruits and immigrants.

I developed a computer simulation model to examine the potential stabilizing effects of floaters on the number of territory holders on the WCSA by allowing replacement of deceased territory holders by floaters. Inputs to the model were the $\hat{\phi}_x$ and $\hat{m}_x$ used in (2) and initial numbers of floaters and territory holders based on the stable age-class vector (w) from the eigenanalysis of (2). I assumed that $\hat{\phi}_x$ was the same for territory holders and floaters. The model included the same assumptions as (2) and



resulted in identical values of $\hat{\lambda}$ when no floaters were included. From time $t$ to $t+1$, individuals in the model experienced three stages (Fig. 1): (1) survival; (2) replacement of deceased territory holders by floaters; and (3) production of fledglings. Juveniles initially survived to be S1 in an available component from which they became either territory holders or floaters. I assumed that (a) existing floaters had priority over vacancies based on Smith (1978) and Arcese (1987) and (b) the likelihood of a floater becoming a territory holder was simply a function of the proportion of individuals in that floating age-class. Remaining vacancies were then filled by available S1 birds with the rest entering the floating component. Therefore, the model included only recruitment. The model generated annual numbers of territory holders and floaters in each age-class.

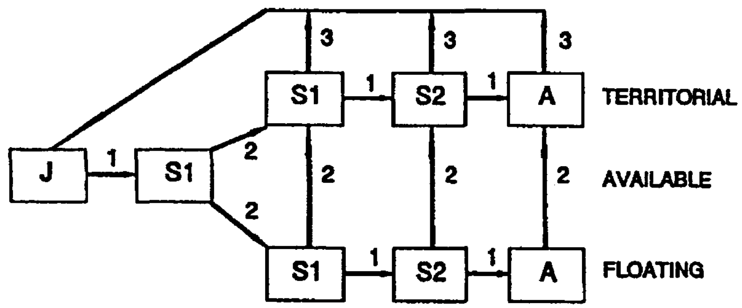


**Fig. 1.** Flowchart of computer simulation model examining effects of floaters on territory holders in a population. Stages and components of the model explained in text.

## RESULTS

### *Population trends on the WCSA*

Estimates of abundance on the WCSA included only territorial individuals since they responded consistently to surveys. Mean total population size on the WCSA was 73.6 (SE = 2.3) individuals based on Jolly-Seber model B estimates (Goodness of fit test: $\chi^2 = 7.06$, 4 df, $P = 0.13$) and 71.5 individuals (SE = 1.8) based on empirical estimates. Annual estimates from Jolly-Seber and empirical methods were similar (Fig. 2). Only empirical estimates for males and females were available because of insufficient data for goodness of fit tests for the Jolly-Seber models. Mean number of males was 37.0 individuals (SE = 0.8) and the mean number of females was 34.6 (SE = 1.0). Based on annual estimates of abundance, the territorial population on the WCSA was significantly stable over the six-year period (Fig. 2) using either empirical ($\hat{\lambda}$ = 1.023, $Z$= 1.05, $P$ = 0.15) or Jolly-Seber estimates of abundance ($\hat{\lambda}$ = 1.029, $Z$ = 0.44, $P$ = 0.33).

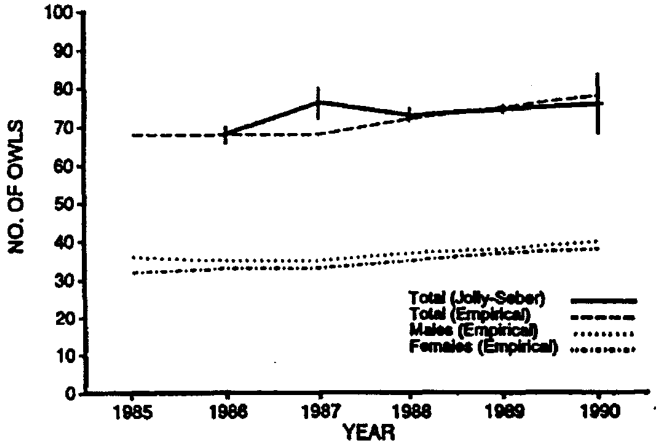


Fig. 2. Empirical and Jolly-Seber estimates for total number and empirical estimates for numbers of male and female northern spotted owls on the WCSA. Vertical bars for Jolly-Seber estimates represent 95% confidence intervals.

Population trends for male spotted owls on the WCSA were significantly stable ($\hat{\lambda} \approx 1$) based on observed and predicted estimates of $\hat{\lambda}$ (Table 1). However, predicted estimates of $\hat{\lambda}$ for females on the WCSA indicated a significantly declining population even though observed estimates of $\hat{\lambda}$ for females indicated stability (Table 1). The parameters used in calculating predictive estimates of $\hat{\lambda}$ indicated males had higher $\hat{\phi}_0$, lower $\hat{\phi}_1$ and $\hat{\phi}_2$, and higher $\hat{\phi}_3$ than females with $\hat{m}_x$ about equal (Table 2). Both males and females began breeding as S1 although at a lower rate than adults. Based on the $\hat{\lambda}$ calculated for females and an initial population of 32 females in 1985 on the WCSA, I predicted 19.6 females in 1990 compared to the 38 observed that year.

*Recruitment and immigration*

Between 1986 through 1990, 57 NTHs were recorded on the WCSA. NTHs on the WCSA either replaced existing territory holders or briefly re-occupied previously abandoned territories. Of these new territory holders, 34 (59.6%) were females and 23 (40.4%) were males. Recruits were 34.8% ($N = 8$) of male NTHs which was significantly higher ($\chi^2 = 4.37$, 1 df, $P = 0.04$) than the 11.8% of recruits making up female NTHs ($N = 4$). Of the female immigrants, 1 (3.3%) was a banded adult migrating from a territory on the RSA. The age-class composition of NTHs was not significantly different between the two sexes or between recruits and immigrants ($\chi^2 = 1.28$-$1.67$, 2 df, $P = 0.43$-$0.53$) and was 43.9% S1, 22.8% S2 and 33.3% A. The mean number of years following birth that banded juveniles entered the territorial population was 1.9 years (SE = 0.3, $N = 16$). Males (mean = 2.2, SE = 0.4, $N = 10$) and females (mean = 1.5, SE = 0.2, $N = 6$) were not significantly different ($t$-test: $t = 1.30$, $P = 0.21$). However, 40.0% of the males did not enter the territorial population until 3 (20%) to 4 (20%) years after their birth, while 50% of the females entered the territorial population after 1 year and 50% after 2 years. Direct evidence of floaters is limited. On 3 occasions, solitary individuals (1 A male; 1 S1 and 1 S2 female) were observed within territories occupied by marked pairs, 100 - 200 m from the roost and nest sites of the territory holders. These individuals did not respond to call surveys but were located accidentally by sight. A male and female subadult exhibited similar behavior during an earlier study on the WCSA (Solis 1983).



TABLE 1. Estimates of $\hat{\lambda}$ for observed and predicted spotted owl populations on the WCSA between 1985 and 1990. $Z$ and $P$ are from 1-tailed $Z$ test (Zar 1984:86) where $H_0$ was $\hat{\lambda} < 1$ or $\hat{\lambda} > 1$.

| | Observed | | Predicted | |
|---|---|---|---|---|
| Estimate | Male | Female | Male | Female |
| $\hat{\lambda}$ | 1.0218 | 1.0352 | 0.9833 | 0.9072 |
| SE($\hat{\lambda}$) | 0.0359 | 0.0247 | 0.0210 | 0.0290 |
| $Z$ | 0.6072 | 1.4251 | 0.7952 | 3.2043 |
| $P$ | 0.2719 | 0.0771 | 0.2132 | 0.0007 |

TABLE 2. Estimates of survival ($\hat{\phi}_x$) and fecundity ($\hat{m}_x$) for male and female northern spotted owls on the WCSA from 1985 through 1990. $\hat{\phi}_x$ based on 112 male and 141 female capture histories.

| | Males | | | Females | | |
|---|---|---|---|---|---|---|
| Parameter | Estimate | $\sigma^2$ | $N$ | Estimate | $\sigma^2$ | $N$ |
| $\hat{\phi}_0$ | 0.3742 | 0.0254 | - | 0.1089 | 0.0021 | - |
| $\hat{\phi}_1$ | 0.5660 | 0.0384 | - | 0.8680 | 0.0008 | - |
| $\hat{\phi}_2$ | 0.7391 | 0.0300 | - | 0.8680 | 0.0008 | - |
| $\hat{\phi}_3$ | 0.9264 | 0.0004 | - | 0.8680 | 0.0008 | - |
| $\hat{m}_1$ | 0.0909 | 0.1667 | 11 | 0.1154 | 0.0850 | 39 |
| $\hat{m}_2$ | 0.0909 | 0.1667 | 11 | 0.1154 | 0.0850 | 39 |
| $\hat{m}_3$ | 0.3324 | 0.1803 | 182 | 0.3824 | 0.1900 | 153 |

*Effects of floaters*

I used the computer simulation model to examine how floaters on the WCSA might affect observed trends in territory holders. I used mean empirical estimates for males and females as the initial number of territory holders which remained constant for all simulations in the model. I varied the number of floaters, expressed as a ratio of floaters to territory holders, for separate simulations. Males and females represented portions of the population experiencing low and high rates of decline, respectively. Populations of male territory holders maintained stability much longer than females even at low floater populations levels (Fig. 3). However, the slopes of the female ($b = 0.732$) and male ($b = 0.715$) relationships ($y = ax^b$) were not significantly different ($t = 0.055$, 8 df, $P = 0.52$), indicating the relationships were parallel but of different magnitudes.

I examined the annual composition of S1, S2, and A age-classes and recruitment over time resulting from the model for changes that might serve as warning signals that an observable decline in the territorial population was imminent. Besides population size, these were the only other factors which changed in the model. Initial size of the territorial component had no effect on how the model behaved, given constant values for the other parameters. To illustrate the trends in age-class composition and recruitment, I used the male parameters with equal numbers of floaters and territory holders to lengthen the decline process and an initial population size of 200 to dampen any radical oscillations resulting from small numbers. Age-class composition of territory holders showed little change during the period when numbers of territory holders remained constant (Fig. 4A). For example, adults declined from an initial high of 97% of territory holders to 87% over a 24-year period and then fluctuated around the latter value. However, the proportion of S1 and A recruits from the floating component to the territorial component changed dramatically (Fig. 4B). S1 recruits increased from 11.5% to 89.5% during the period when numbers of territory holders remained constant and adult recruits showed a corresponding decrease. Overall recruitment remained stable between 8 and 10.5% of the territory holders during the period when territory holders maintained stable numbers.

## DISCUSSION

Male and female northern spotted owls on the WCSA in northwest California had different population dynamics. The WCSA was independent of the surrounding area for maintaining numerical stability of male territory holders. The high juvenile survival rate estimated for males was a function of the high proportion of recruits in the NTHs which resulted in similar observed and predicted population trends. However, the WCSA was dependant on the surrounding area for maintaining numerical stability of female territory holders. Recruits were only a small fraction of female NTHs and immigration was necessary to maintain stable numbers of female territory holders. A similar conclusion was also reached by Anderson et al. (1990) and Thomas et al. (1989). Clearly, the WCSA was part of a larger population. However, if the WCSA became closed to immigration, the population there would eventually become extinct.



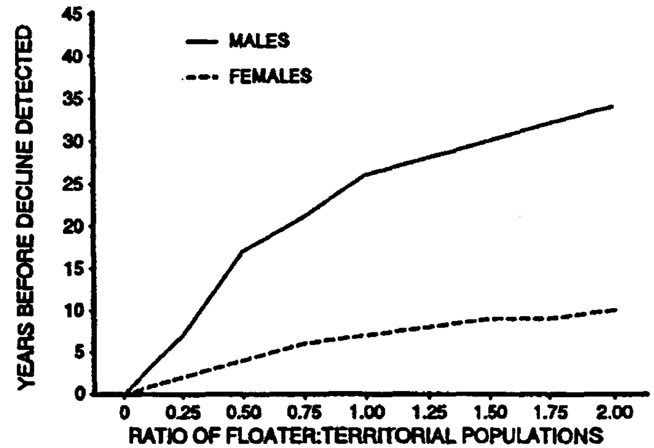


Fig. 3. Simulated effects of varying numbers of floaters on the amount of time to detect declines in the territorial population of the WCSA.

A large proportion of male and female recruits in the WCSA did not become territory holders until at least 2 to 4 years after their birth, indicating that these individuals may have become floaters before entering the territorial population. This evidence, coupled with the limited fortuitous observations, demonstrated that floaters exist in the WCSA population. Therefore, recruitment in northern spotted owl populations may be both spatial and temporal; female juveniles disperse to other subpopulations where they become floaters before eventually becoming territory holders whereas males remain in the subpopulation where they were born and then emerge as territorial birds at a later date. Although some of the immigrants may have been territory holders from outside the WCSA who were displaced from their territories due to logging, I believe the bulk of female NTHs first entered the WCSA as floaters. This is supported by data in Gutiérrez et al. (*in preparation*) where mean dispersal distances for banded female juveniles (23 km) from this study were significantly greater than male juveniles (8 km).

At this point, the degree to which floaters influence or regulate populations on the WCSA is unknown. Studies of other bird species suggests that floaters tend to secretively occupy space defended by territory owners, either ranging over several territories (Smith 1978, Temeles 1987) or occupying home ranges within territories (Arcese 1987). Even though suitable spotted habitat on the WCSA is saturated by territorial birds (Franklin et al. 1990*b*), the large areas defended by northern spotted owls leave sufficient room for the existence of floaters. The size of a territorial population inhabiting a certain area is regulated by territorial behavior only when, (1) part of the potential settlers do not settle and form territories in that area as a result of the territorial behavior of already established

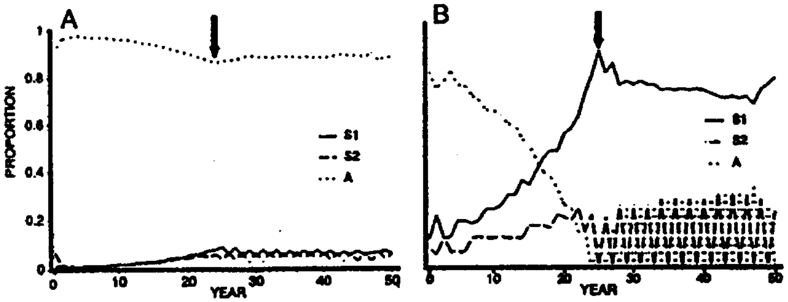


Fig. 4. Simulated age-class composition in territory holders (A) and recruitment of floaters (B) using 200 initial males territory holders and a floater:territory holder ratio of 1. Arrows indicate when numbers of territory holders began to decline.

territory holders, and (2) the proportion of potential settler becoming surplus is density-dependant (Klomp 1972, Patterson 1980). Therefore, I cannot conclude that territorial behavior regulates the population without information on the size of the floating component (Sinclair 1989). However, there is sufficient evidence to support the concept as a viable hypothesis which needs further examination. The same mechanism also has been proposed for maintaining long-term stability in other raptor populations such as peregrine falcons (*Falco peregrinus*) (Nelson 1983), European kestrels (*Falco tinnunculus*) (Village 1983), and tawny owls (*Strix aluco*) (Hirons 1985). In these species, long-term stability appeared to be regulated by territorial behavior with the number of floaters being limited by resources, such as prey.

The current management plan for northern spotted owl populations proposes to protect Habitat Conservation Areas (HCAs) containing at least 20 pairs of owls spaced at least 19 km apart (Thomas et al. 1990). Under this plan, it is expected that habitat not contained in HCAs will be reduced in suitability for spotted owls due to logging. HCAs may, therefore, eventually represent discrete subpopulations. In this case, the maintenance of stable female populations on a given HCA probably will depend on immigration from other HCAs. Although Lande (1988) and Noon and Biles (1990) found that $\lambda$ from life-table analyses was most sensitive to adult survival, population stability on individual HCAs will depend heavily on the maintenance of female floater populations through immigration.

An important assumption of the management plan is the ability to monitor spotted owl populations and to adjust management strategies if necessary (Thomas et al. 1990). Currently, territorial birds are the only component of spotted owl populations that can be measured in the field; floaters can only be measured indirectly. If spotted owl populations are regulated by territorial behavior, the existence of a large floating population could buffer observable declines as predicted by Wilcove and Terborgh (1984). For slowly declining spotted owl populations, declines in territorial owls would not be detected for 15 - 25 years, even at low floater densities. Consequently, monitoring life-



table parameters (such as survival and fecundity) at the scale of the WCSA may not provide a complete evaluation of population stability because of the spatial and temporal effects of immigration and recruitment.

Advance warning signals of potential instability are necessary to exercise options for adjusting management strategies. A warning signal should be measurable in the field, and have a high rate of change over a short period of time. Monitoring the composition of recruits from the floating population may provide an important warning signal of impending long-term population instability. If the floating population is becoming exhausted through increased recruitment to the territorial component, then an increasing proportion of vacancies will be filled by S1 individuals.

Management of spotted owl populations is predicated on understanding the mechanisms which regulate them. While my results support the current strategy proposed for managing northern spotted owl populations, the question remains as to whether the size and number of HCAs will be sufficient to support viable spotted owl populations well into the future.

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# EXHIBIT E

# WILDLIFE MONOGRAPHS

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## NATAL AND BREEDING DISPERSAL OF NORTHERN SPOTTED OWLS

by

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BRIAN L. BISWELL, AMY ELLINGSON, E. CHARLES MESLOW,
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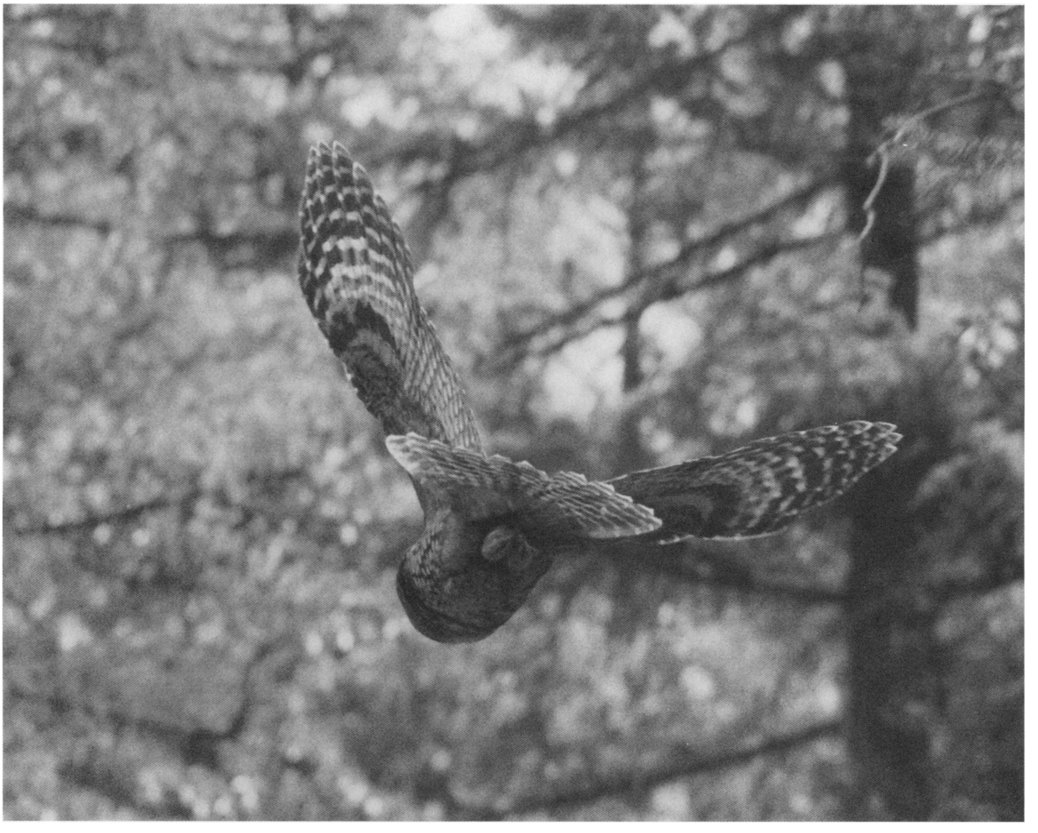

FRONTISPIECE. A northern spotted owl dispersing in western Oregon (Photo from U.S. Forest Service files).

# NATAL AND BREEDING DISPERSAL OF NORTHERN SPOTTED OWLS


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*Abstract:* We studied the dispersal behavior of 1,475 northern spotted owls (*Strix occidentalis caurina*) during banding and radio-telemetry studies in Oregon and Washington in 1985–1996. The sample included 324 radio-marked juveniles and 1,151 banded individuals (711 juveniles, 440 non-juveniles) that were recaptured or resighted after dispersing from the initial banding location. Juveniles typically left the nest during the last week in May and the first two weeks in June ($\bar{x} \pm$ SE = 8 June $\pm$ 0.53 days, $n$ = 320, range = 15 May–1 July), and spent an average of 103.7 days in the natal territory after leaving the nest (SE = 0.986 days, $n$ = 137, range = 76–147 days). The estimated mean date that juveniles began to disperse was 19 September in Oregon (95% CI = 17–21 September) and 30 September in Washington (95% CI = 25 September–4 October). Mean dispersal dates did not differ between males and females or among years. Siblings dispersed independently. Dispersal was typically initiated with a series of rapid movements away from the natal site during the first few days or weeks of dispersal. Thereafter, most juveniles settled into temporary home ranges in late October or November and remained there for several months. In February–April there was a second pulse of dispersal activity, with many owls moving considerable distances before settling again in their second summer. Subsequent dispersal patterns were highly variable, with some individuals settling permanently in their second summer and others occupying a series of temporary home ranges before eventually settling on territories when they were 2–5 years old. Final dispersal distances ranged from 0.6–111.2 km for banded juveniles and 1.8–103.5 km for radio-marked juveniles. The distribution of dispersal distances was strongly skewed towards shorter distances, with only 8.7% of individuals dispersing more than 50 km. Median natal dispersal distances were 14.6 km for banded males, 13.5 km for radio-marked males, 24.5 km for banded females, and 22.9 km for radio-marked females. On average, banded males and females settled within 4.2 and 7.0 territory widths of their natal sites, respectively. Maximum and final dispersal distances were largely independent of the number of days that juveniles were tracked. Although statistical tests of dispersal direction based on all owls indicated that direction of natal dispersal was non-random, the mean angular deviations and 95% CI's associated with the samples were large, and $r$-values (vector length) were small. This lead us to conclude that significant test results were the result of large sample size and were not biologically meaningful. Our samples were not large enough to test whether dispersal direction from individual territories was random.

In the sample of radio-marked owls, 22% of males and 44% of females were paired at 1 year of age, but only 1.5% of males and 1.6% of females were actually breeding at 1 year of age. At 2 years of age, 68% of males and 77% of females were paired, but only 5.4% of males and 2.6% of females were breeding. In contrast to the radio-marked owls, most juveniles that were banded and relocated at 1 or 2 years of age were paired, although few were breeding. Although recruitment into the territorial population typically occurred when owls were 1–5 years old, 9% of banded juveniles were not recaptured until they were > 5 years old. We suspect that our estimates of age at recruitment of banded owls are biased high because of the likelihood that some individuals were not recaptured in the first year that they entered the territorial population.

A minimum of 6% of the banded, non-juvenile owls on our demographic study areas changed territories each year (breeding dispersal). The likelihood of breeding dispersal was higher for females, young owls, owls that did not have a mate in the previous year, and owls that lost their mate from the previous year through death or divorce. Mean and median distances dispersed by adults were shorter than for juveniles, and did not differ between the sexes or study areas ($\bar{x}$ = 6.1 km, median = 3.5 km). Owls that were 1–2 years old tended to disperse farther than owls that were > 2 years old. The direction of post-natal dispersal did not differ from random.

The large nonforested valleys of western Oregon (Willamette, Umpqua, Rogue Valleys) acted as barriers to dispersal between the Coast Ranges and the Cascade Mountains. However, dispersal did occur between the Coast Ranges and Cascade Mountains in the forested foothills between the non-forested valleys. Forest landscapes traversed by dispersing owls typically included a fragmented mosaic of roads, clear-cuts, non-forest areas, and a variety of forest age classes ranging from young forests on cutover areas, to old-growth forests ≥ 250 years old.

Our data fit the general pattern observed in birds in that females dispersed farther than males and dispersal distances were negatively skewed towards short distance dispersers. Comparison of data from radio-marked and banded owls demonstrated that the negatively skewed distribution of dispersal distances represented the actual distribution of dispersal distances, and was not the result of small study area bias on recaptures. We found no correlation between dispersal distance and age at first breeding, which suggests that reproductive fitness is not affected by dispersal distance. We observed only 3 cases of close inbreeding (parent-offspring or sibling pairs) in thousands of pairs of spotted owls, suggesting that dispersal results in a very low incidence of close inbreeding in the spotted owl. However, inbreeding with more distant relatives was common.

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**Key words:** banding, dispersal, inbreeding, mortality, northern spotted owl, Oregon, predation, radiotelemetry, *Strix occidentalis caurina,* Washington.

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CONTENTS



## INTRODUCTION

Dispersal behavior is highly variable in birds, ranging from highly philopatric species that often settle on or near the territory where they were born (Koenig and Pitelka 1979, Stacey and Ligon 1987, Bowen et al. 1989, Russell and Rowley 1993, Daniels and Walters 2000) to species that typically disperse considerable distances before settling (Beske 1982, Newton and Marquiss 1983, Vander Wall et al. 1983, Korpimäki and Lagerström 1988, Marti 1999). Although there is great variation in dispersal patterns among and within species, a consistent trend in most birds is for females to disperse farther than males (Greenwood 1980, Newton and Marquiss 1983, Small and Rusch 1989, Ellsworth and Belthoff 1997, Marti 1999). This is the reverse of the pattern observed in most mammals, in which males tend to disperse farther than females (Baker 1978, Greenwood 1980). Greenwood (1980) suggested that sex-biased dispersal may be a function of the type of resource that is defended, with female-biased dispersal prevailing in species that defend foraging areas (most birds) and male-biased dispersal predominating in species that defend mates (many mammals). The logic underlying this hypothesis is that in species that defend foraging areas, males invest more time in prospecting for and defending a suitable territory, whereas females have more time to travel between multiple territories in search of a suitable male.

Sexual differences in dispersal and the highly variable nature of dispersal have stimulated an extensive debate regarding the causes of dispersal (e.g., Greenwood 1980; Shields 1982, 1983; Moore and Ali 1984; Bull et al. 1987; Arcese 1989; Johnson and Gaines 1990; Koenig et al. 1992; McPeek and Holt 1992; Holt and McPeek 1996). This discussion has tended to focus on dispersal as a mechanism for (1) avoiding inbreeding with closely related individuals (Howard 1960, Greenwood et al. 1978, Packer 1979, 1985, Greenwood 1980, Shields 1983), (2) reducing intrasexual competition for mates or resources (Murray 1967, Moore and Ali 1984, Waser 1985, Small and Rusch 1989, Tonkyn and Plissner 1991), or (3) increasing individual fitness in patchy landscapes with spatiotemporal or chaotic variation in habitat quality (Holt 1985, McPeek and Holt 1992, Holt and McPeek 1996). Because there are so many exceptions to almost every generalization regarding dispersal, some have cautioned against seeking a single causal mechanism (Koenig et al. 1992, Russell and Rowley 1993).

Regardless of the reasons for dispersal, patterns of movement and behavior of non-territorial "floaters" can have profound effects on population dynamics and may mask long-term changes in populations (Thomas et al. 1990, Stacey and Taper 1992, Lamberson et al. 1994, Rhoner 1996). In addition, dispersal is the mechanism by which genes are transmitted within populations. As a result, dispersal behavior is a primary concern in reserve design for threatened and endangered species (Murphy and Noon 1992, Harrison et al. 1993, Lamberson et al. 1994). A recent example is the Northwest Forest Plan, which resulted in the retention of an extensive network of large, old-forest reserves on federal lands in western Washington, Oregon and northern California (FEMAT 1993, USDA/USDI 1994). These reserve areas are typically spaced 10–20 km apart. They are designed to provide habitat for spotted owls, marbled murrelets (*Brachyramphus marmoratus*), and other species that utilize old forests and associated riparian areas. This reserve design was established based on the premise that spotted owls would interact as a metapopulation within and among the reserves, with adequate dispersal between reserves to maintain genetic variation and recolonize unoccupied territories (Thomas et al. 1990, Murphy and Noon 1992, FEMAT 1993, USDA/USDI 1994).

A major difficulty in the development of the Northwest Forest Plan was that information on dispersal of spotted owls was limited. Previous studies were limited to small samples of radio-marked owls, most of which were tracked for less than a year, and which rarely lived long enough to acquire territories (Allen and Brewer 1985, Gutiérrez et al. 1985, Miller and Meslow 1985, Laymon 1988, Miller 1989, Miller et al. 1997). As a result, management plans for the spotted owl, and simulation models used to evaluate those plans, necessarily included many untested assumptions regarding dispersal (e.g., Lande 1988; Doak 1989; Lamberson et al. 1992, 1994; Holthausen et al. 1995).

In this paper, we describe the dispersal behavior of northern spotted owls based on relocations of banded owls and radio-marked owls in Oregon and Washington. Our specific objectives were to (1) investigate sexual differences in dispersal, (2) describe the chronology of natal dispersal, (3) describe integration of young owls into the territorial population, (4) describe effects of landscape features on dispersal, (5) describe social factors associated with breeding dispersal, (6) determine if estimates of dispersal parameters differed between banded and radio-marked owls, and (7) determine if dispersal distance was positively correlated with the age when owls first nested. We discuss how our results fit with previous studies of dispersal in birds and with some of the hypotheses that have been suggested regarding causes of dispersal. We also discuss our findings in the context of current management plans for the owl, and we provide suggestions that modelers might use to develop more realistic spatial simulation models for spotted owls.

*Acknowledgments.*—This study was a group effort that would not have been possible without the dedicated efforts of many biologists and field technicians who banded, recaptured, and radio-tracked spotted owls. The main cast of characters included L. S. Andrews, G. Arnold, D. Aubuchon, D. K. Barrett, M. Blow, R. R. Bown, M. Brown, J. A. Burns, B. R. Casler, A. D. Center, G. S. Center, N. L. Duncan, R. H. Espinosa, C. C. Foster, R. K. Forson, A. R. Giese, J. H. Guetterman, J. F. Harper, T. Hines, D. S. Hopkins, R. B. Horn, S. P. Horton, M. Kinsey, D. L. Kelso, R. Leach, J. C. Lewis, J. B. Lint, W. D. Logan, R. Lowell, D. Manson, K. J. Maurice, C. McCafferty, G. S. Miller, G. W. Mires, J. Mowdy, M. Nixon, C. Oakley, I. A. Otto, L. B. Page, J. P. Perkins, M. R. Roan, S. E. Salmons, R. Schnoes, P. A. Shaklee, G. Sitter, R. J. Straub, M. St. Peters, J. K. Swingle, M. Townsend, J. Witt, C. Zabel, and J. Zisa. In addition to helping with field work, F. M. Oliver made most of the plastic color bands that were used in our study. His craftsmanship and attention to

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## STUDY AREAS

We banded and monitored owls on 12 large (1,075–15,216 km$^2$) demographic study areas that were originally selected as long-term monitoring areas for spotted owls on federal lands in Oregon and Washington (Fig. 1)(Franklin et al. 1996). Many of these areas were adjacent to each other, such that owls banded in 1 study area were often detected in another study area after they dispersed (Fig. 1). In addition, concurrent surveys for spotted owls were conducted by timber companies, consulting firms and state agencies in many other areas in Oregon and Washington, such that banded owls were often recaptured or resighted even if they left our demographic study areas. Ultimately, therefore, our study area included much of the range of the northern spotted owl in Oregon and Washington.

All study areas were dominated by rugged mountains covered by temperate coniferous forests. Forests in more mesic regions (western Washington and northwest Oregon) were typically dominated by Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and western redcedar (*Thuja plicata*). In more xeric areas (southwestern Oregon and the east slope of the Cascades Mountains), forests were typically dominated by mixtures of grand fir (*Abies grandis*), Douglas-fir, ponderosa pine (*Pinus ponderosa*), incense cedar (*Libocedrus decurrens*), and western white pine (*Pinus monticola*). In the Klamath Mountains of southwestern Oregon, evergreen hardwoods such as tanoak (*Lithocarpus densiflorus*), California laurel (*Umbellularia californica*), and Pacific madrone (*Arbutus menziesii*) commonly occurred in mixed-species stands with conifers, including Douglas-fir, grand fir, incense cedar, western white pine or redwoods (*Sequoia sempervirens*).

Landscapes within our study areas typically included a complex mosaic of forests, roads, clear-cuts and non-forest cover types. Age and structure of forests was highly variable, but typically included areas of old-growth and mature forest intermixed with younger forests growing on areas that had been burned or harvested. Large lowland valleys dominated by agriculture and urban development were interspersed within and among many study areas (Fig.1).

## METHODS

### Field Methods

Demographic studies on the 12 study areas began in 1985–1990, and continued through 1996. Owl territories in each study area were surveyed each year to resight marked owls, band unmarked owls, locate nests, and determine the number of young produced by each resident owl (Franklin et al. 1996). Adult owls were marked with a U. S. Fish & Wildlife Service leg band and a colored leg band when first captured, so that they could be visu-

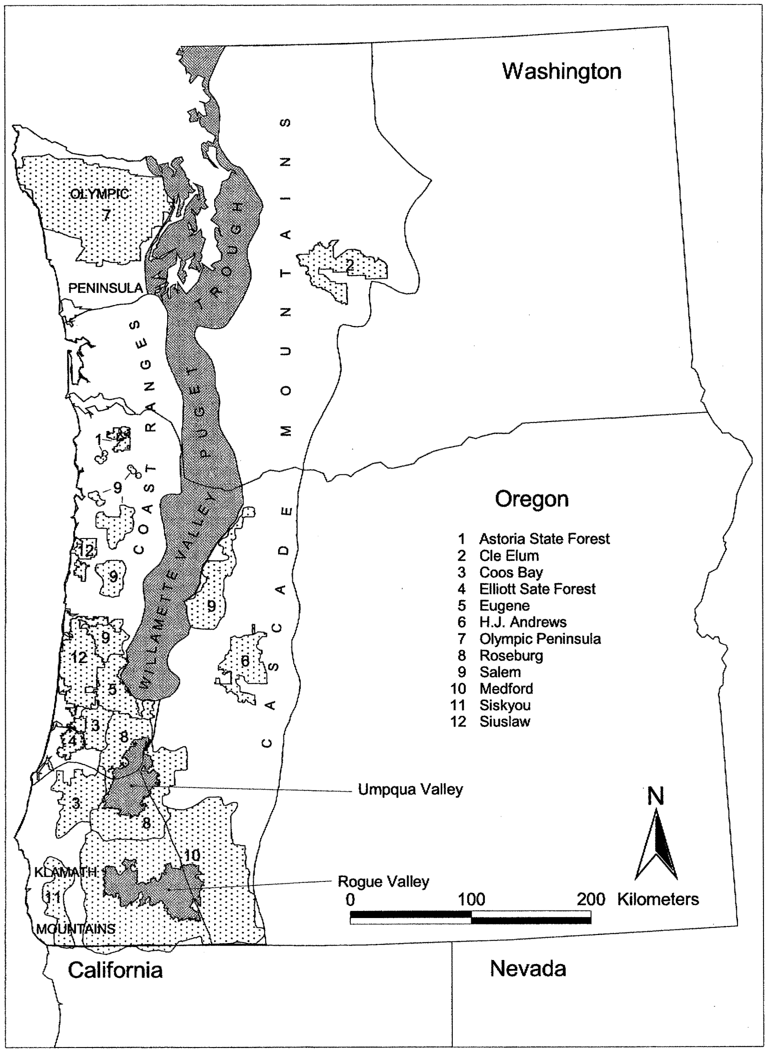


Fig. 1. Demographic study areas in Oregon and Washington where spotted owls were banded or radio-marked in 1985–1996.

ally identified in subsequent years without recapture (Forsman et al. 1996, Franklin et al. 1996). Juveniles were banded with a U. S. Fish & Wildlife Service band and a red-and-white color band. If they were resighted in subsequent years, owls banded as juveniles were recaptured, at which time their red-and-white bands were replaced with unique color bands. Spotted owls are easily captured with noose poles (Forsman 1983), so we were almost always able to recapture and identify juveniles after they were relocated on a new territory. Adults were identified by observing their color bands at close range with binoculars. Adults that dispersed were sometimes recaptured to confirm their identity or change their color bands.

We used acoustic lure and live lure surveys to resight banded owls and to locate nests and juvenile owls (Forsman 1983, Franklin et al. 1996, Reid et al. 1999). In most cases, surveys did not include a complete coverage of the entire study area but

were conducted at many different locations where there was a history of occupancy by spotted owls. Although study area boundaries changed somewhat over the years, most areas and most territories were searched each year, using a standardized protocol to confirm bands, band new owls and document the number of young produced by each owl (Franklin et al. 1996). Monitoring efforts on demographic study areas were further supplemented by surveys on adjacent areas, where private landowners and consulting firms conducted surveys or mark-recapture studies of spotted owls and occasionally resighted our banded owls. Sex of banded owls was determined from vocalizations and behavior (Forsman et al. 1984, Franklin et al. 1996) or from blood samples (Dvorák et al. 1992, Fleming et al. 1996).

In addition to observations of banded owls, we radio-marked 386 juvenile spotted owls in 1991–95 and attempted to track them for 1–2 years. Juveniles were radio-marked on the Olympic and Cle Elum Study Areas in Washington (n = 170) and on the Siuslaw, Eugene, and Roseburg Study Areas in western Oregon (n = 216)(Fig. 1). Sex of 318 of the radio-marked juveniles was determined from blood samples, necropsies, or vocalizations. Sex of 68 of the radio-marked juveniles was unknown. Transmitters weighed 5.5 g (Holohil Systems Ltd., Model RI-2C), were tied and glued to the central tail feathers in late July or August (Reid et al. 1996a), and had an expected field life of 12 months (maximum = 23 months).

We defined natal dispersal as the movement the individual makes from its birth site to the place where it reproduces or would have reproduced if it had survived and found a mate (Howard 1960). We defined breeding dispersal as any case in which a non-juvenile owl (≥ 1 year old) moved between territories where it had the opportunity to breed, regardless of whether it bred or not (Daniels and Walters 2000). Breeding dispersal could occur multiple times during the lifetime of an individual if it occupied a series of different territories or moved back-and-forth between 2 or more distinct territories in different years. We excluded cases where movements involved use of alternate nest sites within the same territory in different years. We also excluded cases where owls were located at 2 different territories during the same summer because such movements usually involved non-breeding birds and probably represented prospecting behavior (Reed et al. 1999) rather than dispersal.

For radio-marked juveniles, we considered dispersal to have started when owls moved ≥ 2.4 km from their natal site. The only exceptions to the 2.4-km rule were 5 cases where juveniles settled on territories that were < 2.4 km from their natal sites. We used the 2.4-km cutoff for initiation of dispersal because we were reasonably sure that, once juveniles moved more than 2.4 km from the natal site, they were outside the home range of their parents (Forsman et al. 1984:21).

Dates when radio-marked owls started to disperse were estimated as the midpoint between the last location at the natal site and the first location after dispersal started. This approach was necessary because we did not relocate every owl each day. Thus there was undoubtedly some error in the estimates of individual dispersal dates. However, we had no reason to believe that individual errors were biased in 1 direction, so estimates of means should have been unbiased.

Radio-marked juveniles were relocated by triangulating with a portable receiver (Telonics model TR2) and hand-held antenna (Telonics model RA-2A) or a pair of RA-2A antennas mounted on an airplane (Guetterman et al. 1991). Locations determined by triangulation were often followed up by homing in on owls at their roosts to visually confirm that they were alive. Most relocations (98.0%) of radio-marked owls were obtained during daylight hours and thus represented roost locations.

After radio-marked juveniles started to disperse, the average interval between sequential relocations was 5.390±0.092 days in Oregon ($n$ = 5,200), 14.345±1.014 days

on the Olympic Peninsula ($n$ = 368), and 12.177±0.385 days on Cle Elum ($n$ = 1,239). After the first year of life (1 June–31 May) the average interval between sequential relocations of radio-marked owls increased to 9.565±0.271 days in Oregon ($n$ = 2,742), 34.678±3.186 days on the Olympic Peninsula ($n$ = 174), and 30.869±2.516 days on Cle Elum ($n$ = 183). We reduced the frequency of relocations after the first year of life because many owls became more sedentary and because owl trackers were busy banding, radio-marking and tracking the next cohort of juveniles.

We usually were able to follow radio-marked juveniles by tracking them from the ground, but aircraft flights were scheduled as needed to search for missing birds. Aircraft searches were typically conducted by flying a grid pattern, working outward from the last known location for distances of 30–40 km. If a missing bird was not located on 1 flight, we continued to search for it on subsequent flights when we searched for other missing birds, such that the cumulative search effort from aircraft flights typically included our study areas plus the areas 50–100 km beyond the study area boundaries.

Radio-marked juveniles were tracked until they died or until the signal was lost. Transmitters were replaced on 100 individuals during their second summer, so that they could be followed for approximately 2 years. After transmitters failed we were still able to determine the fate of some of the radio-marked owls because they were recaptured as territorial birds in our demographic studies.

To determine when juvenile owls entered the territorial population, we tried to determine the status of all radio-marked and banded owls that were relocated each year. Owls were typically relocated several times in their day roosts during the breeding season to determine if they were paired or nesting. Nesting status and pair status were determined by imitating spotted owl vocalizations (acoustic lure technique) in roost areas to see if a mate was present, and by feeding owls live mice to see if they would deliver them to a nest or fledged young (live lure technique) (Franklin et al. 1996, Reid et al. 1999). These data were used to estimate the proportion of owls in each age cohort that were single, breeding, or paired but not breeding. We estimated recruitment rates of radio-marked owls based on the proportion of 1-year-old and 2-year-old owls that were paired. For banded owls we estimated recruitment rates as the proportion of owls first recaptured in each age class, regardless of whether they were paired or not.

To evaluate whether territorial behavior influenced movements of floaters we compared the distribution of relocations of radio-marked juveniles with the distribution of the territories of resident owls. For this evaluation we made the simplifying assumption that the area of primary use of resident owls corresponded to a 1.5 km radius around each nest site, and we limited the analysis to a portion of the Roseburg Study Area that was completely surveyed each year to locate all resident owls (Reid et al. 1996*b*).

## Statistical Analyses

All statistical analyses were performed with program SPSS (Norušis 1990) or program SAS (SAS Institute 1997). We used 1-way ANOVA to evaluate year-effects and sex-effects on dates when owlets left the nest, number of days spent in the natal area, and dispersal dates. Dates when owlets left the nest and number of days spent in the natal area were estimated for 4 years in Oregon (1991–94) and 2 years in Washington (1991–92). Time spent in the natal area could not be computed for other cohorts of radio-marked juveniles because we did not visit nests frequently enough to determine approximate dates when owlets left the nest.

Variables measured relative to distance and direction of natal dispersal were: (1) the straight-line distance (MAXD) and azimuth (MAXAZ) to the farthest location from the natal site, (2) the straight-line distance and azimuth from the natal site to

the final location where the owl was located (FIND, FINAZ), regardless of the number of times the owl dispersed during the study or its age when last recaptured, (3) average distance moved per day (DDAY) during each time interval between sequential relocations, and (4) distance from natal site to owl at each relocation (DNEST). Estimates of DDAY were calculated by dividing the distance traveled between sequential relocations by the number of days in the interval, and were limited to cases where the interval between sequential relocations was $\leq$10 days. Average DDAY and DNEST were estimated for each weekly interval after dispersal started by averaging all estimates from all owls that were sampled in each weekly interval.

To evaluate the influence of dispersal distance on lifetime reproduction we used ANOVA to test the null hypothesis that mean dispersal distances did not differ among owls that first attempted to nest at 1, 2, 3, or 4+ years of age. This analysis was based on banded owls because the number of radio-marked owls that nested at 1 year of age was small.

For breeding dispersal the frame of reference for calculations of MAXD, MAXAZ, FIND, and FINAZ, was the initial banding location rather than the natal site. Differences in mean dispersal distances between groups were tested with 1-way ANOVA. All distances were log-transformed for analysis to improve normality.

For radio-marked juveniles we used regression analysis to examine the degree of correlation between MAXD and FIND and the number of days that owls were tracked after they initiated dispersal. For these tests we only used owls that were tracked $\geq$ 30 days after initiating dispersal. To determine if banded owls tended to keep moving away from their natal sites when they dispersed more than once, we tested the null hypothesis that mean FIND did not differ depending on the number of times that an owl dispersed during its lifetime. For the latter test we used 1-way ANOVA to compare mean FIND for owls that dispersed 1, 2, or 3 times.

Shields (1983) proposed the "effective dispersal distance" (mean or median dispersal distance ÷ mean distance between pairs or territories in the population) as a method for comparing the relative degree of philopatry in species with different territory sizes and population densities. He defined a "philopatric" species as one in which the effective dispersal distance was $\leq$ 10. To determine the denominator for calculations of effective dispersal distance, we selected a 1,011-km$^2$ area in the Roseburg Study Area that was completely surveyed every year, and divided the area by the average number of pairs detected per year in 1990–96 ($\bar{x}$ = 56). This produced an estimate of 1 pair for every 1,805 ha, which, assuming that pairs were hexagonally packed, indicated an average spacing of 3.5 km between territory centers. We chose this approach because we did not have data on density of owls from all study areas, and because it was simple and repeatable.

Mean dispersal azimuths ($\bar{\alpha}$) and lengths of mean dispersal vectors ($r$) were calculated as described by Batschelet (1981:10). We used the mean angular deviation ($s$) to estimate the amount of dispersion around mean dispersal azimuths (Zar 1984:431). Confidence limits around mean azimuths were calculated as per Zar (1984:432). We tested the hypothesis that dispersal azimuths did not differ from random with a $\chi^2$ test ($\chi^2 = 2nr^2$ with 2 df) (F. L. Ramsey, Oregon State University, personal communication). To determine if final dispersal azimuths of siblings were correlated we used a $t$-test to evaluate the null hypothesis that the mean difference between final dispersal azimuths of siblings did not differ from 90°, where $t = \bar{x} - 90°/\sqrt{\text{var}/n - 1}$. The logic for this test was that if there was no tendency for siblings to disperse in the same direction or in opposite directions, then the average difference between dispersal azimuths of siblings should be 90°.

For non-juvenile owls we calculated a minimum estimate of the proportion of the territorial population dispersing per

Table 1. Number of spotted owls banded in Oregon and Washington that dispersed 1 or more times, 1985–1996.

| No. of dispersal events per owl | No. of owls subdivided by age (in years) when first banded | | | | Totals | |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3+ | No. | % |
| 1 | 595 | 60 | 54 | 252 | 961 | 83.5 |
| 2 | 105 | 9 | 17 | 7 | 168 | 14.6 |
| 3 | 9 | 2 | 3 | 5 | 19 | 1.7 |
| 4 | 2 | 0 | 1 | 0 | 3 | 0.3 |
| Totals | 711 | 71 | 75 | 294 | 1,151 | 100.0 |

year by dividing the number of owls that moved in a given year by the number of owls in the marked population that did not move or that disappeared and were never seen again. This was a minimum estimate of the annual breeding dispersal rate since we did not know if birds that disappeared were dead or had dispersed and gone undetected. For this analysis we assumed that dispersal occurred in the first year an owl was missing from its territory, regardless of when it was eventually re-observed at a new territory. This analysis was based on 4,917 records where we knew whether the owl moved, stayed on its territory, or disappeared in a given year, and where we determined the status of the mate from the previous year based on repeated field surveys. We restricted this analysis to 6 study areas where researchers provided a complete record of all field surveys between 1990–1996. We used $\chi^2$ tests to compare proportions of owls that dispersed in different years.

We used 1-way ANOVA to conduct univariate tests of the null hypotheses that breeding dispersal was not influenced by sex, age in the previous breeding season, or social factors. Social factors (SF) that we examined were based on the status of the owl in the breeding season prior to the year in which it was found at a new territory, or the status of the owl's previous mate in the year that the owl was found at a new territory, as follows:

1 = owl did not have a mate in previous year.
2 = mate from previous year died or disappeared and was never seen again, despite repeated surveys.
3 = mate from previous year moved to new territory.
4 = mate from previous year still at the original territory.

Age in the breeding season prior to the year that an owl was relocated at a new territory (AGE) was classified as 1, 2, or 3+, with all owls that were ≥ 3 years old classified as 3+. Owls not banded as juveniles were assigned to age classes based on plumage characteristics (Forsman 1981).

In addition to univariate tests of factors related to breeding dispersal, we used 2 different logistic regression analyses to examine the simultaneous influence of sex, age, social factors and breeding status on breeding dispersal. In 1 analysis we treated dispersal as the response variable (Yes/No) with explanatory categorical variables SEX, AGE, and SF. In the other we used the same response variable, with explanatory variables SEX, AGE and nesting status (Yes/No) in the previous breeding season. The latter analysis was based on 4,877 cases where we were reasonably sure that nesting did or did not occur, based on repeated relocations of the owls in each territory. To compare the relative likelihood or "odds" of dispersal among groups with different combinations of age, sex and social factors, we computed 95% CI's on the odds ratios from the logistic regression models (Ramsey and Schafer (1997:575–577). All means are expressed as $\bar{x} \pm$SE.

## RESULTS

During 1985–1996 we banded 7,682 spotted owls (3,683 juveniles, 3,999 non-

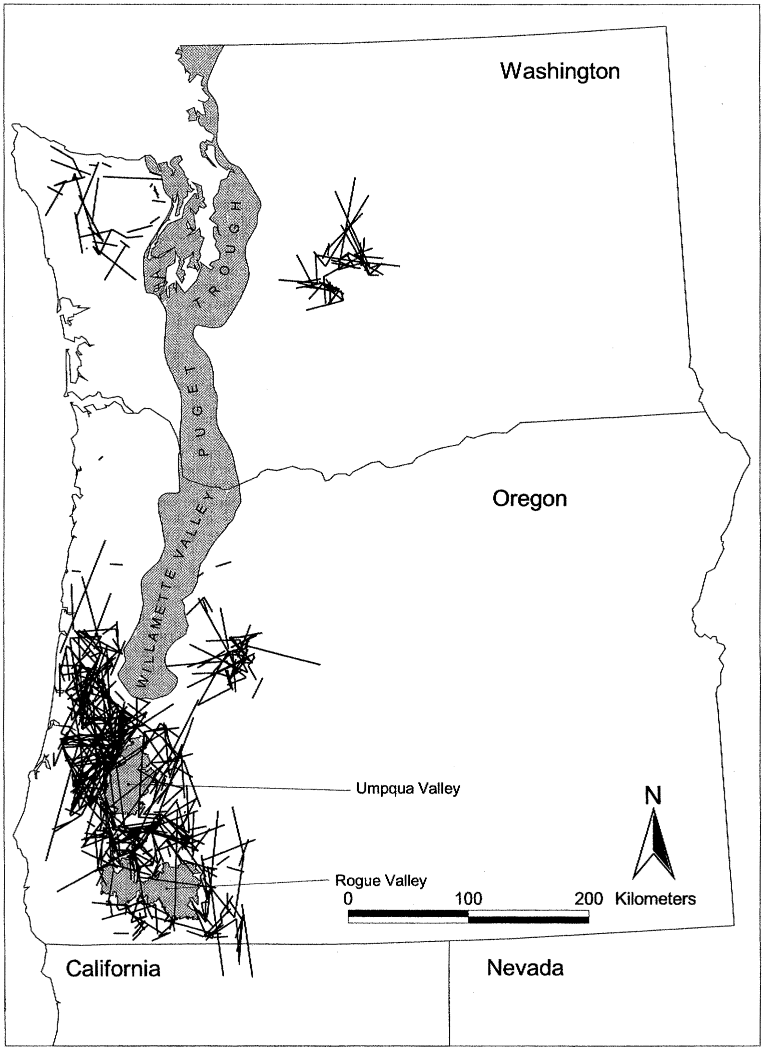


Fig. 2. Straight-line dispersal paths of 711 juvenile spotted owls banded in Oregon or Washington and recaptured after dispersing from their natal sites, 1985–1996. Shaded areas indicate lowland valleys characterized by non-forest habitat.

juveniles) and documented 1,366 dispersal events by 1,151 individuals (711 juveniles, 440 non-juveniles) (Table 1, Figs 2–3). For banded owls whose sex was known, records of dispersal were about equally distributed between males and females for juveniles (376 males, 327 females) and non-juveniles (231 males, 209 females). In most cases, we observed only 1 (83.5%) or 2 (14.6%) dispersal events per banded owl, but there were 19 cases where owls dispersed 3 times (1.7%), and 3 cases (0.3%) where owls dispersed 4 times (Table 1).

Of the 386 juveniles that were radio-marked in 1990–95, we obtained dispersal data on 324. The other 62 juveniles either died ($n$ = 45), molted their transmitters ($n$ = 5), had transmitter failure ($n$ = 3), or were lost due to unknown causes ($n$ = 9) before initiating dispersal. Daily rates of

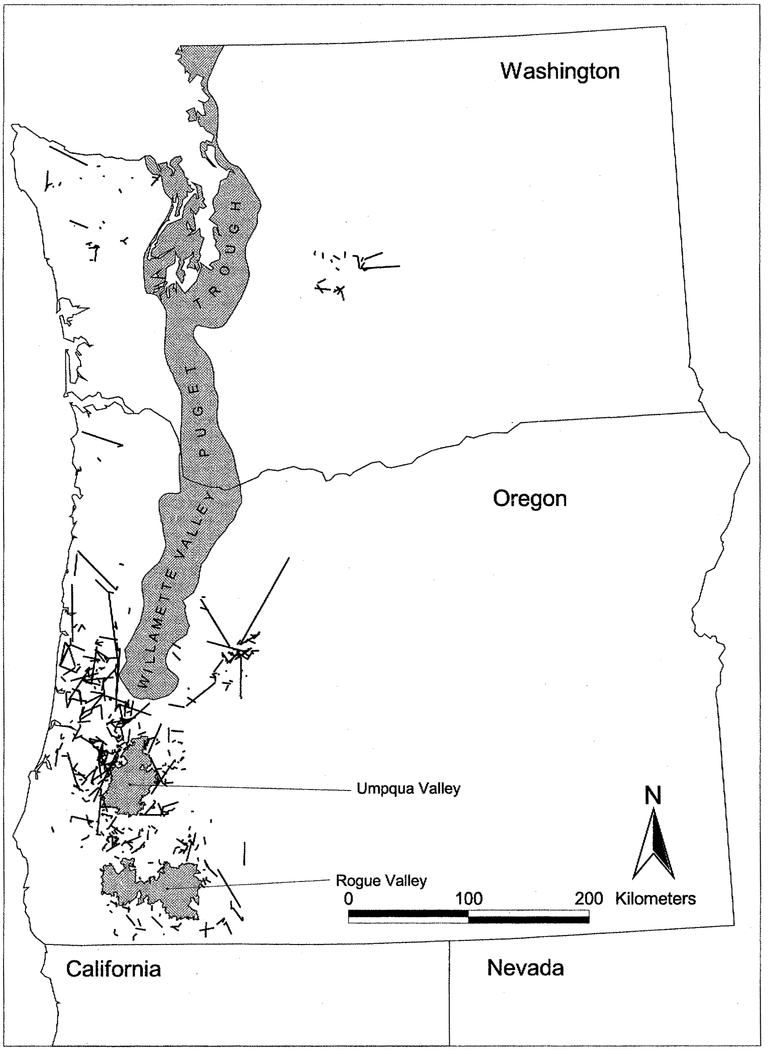


Fig. 3. Straight-line dispersal paths of 440 non-juvenile spotted owls that were banded in Oregon or Washington and recaptured or resighted after moving to new territories, 1985–1996. Shaded areas indicate lowland valleys characterized by non-forest habitat.

movement and dispersal direction were calculated for all radio-marked owls that dispersed, regardless of their sex or how many days they were tracked after they started dispersal. Estimates of mean MAXD and mean FIND of radio-marked owls were restricted to 236 individuals of known sex (114 males, 122 females) that we tracked for ≥ 30 days after they began to disperse.

## Chronology of Natal Dispersal

Mean dates when juveniles were first located out of the nest were 8 June±0.53 days in Oregon ($n$ = 320, range = 15 May–1 July) and 18 June±1.67 days in Washington ($n$ = 77, range = 13 May–15 July). Mean dates when owlets left the nest varied among years in Oregon (range of means = 4–9 June, $F_{3,312}$ = 5.41, $P$ =

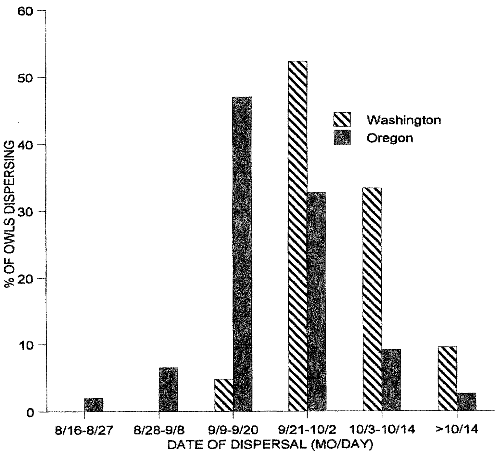


Fig. 4. Timing of dispersal of radio-marked juvenile spotted owls in Oregon and Washington, 1990–1995. Graph indicates percent of individuals initiating dispersal in different 12-day intervals. $N$ = 154 in Oregon and 20 in Washington.

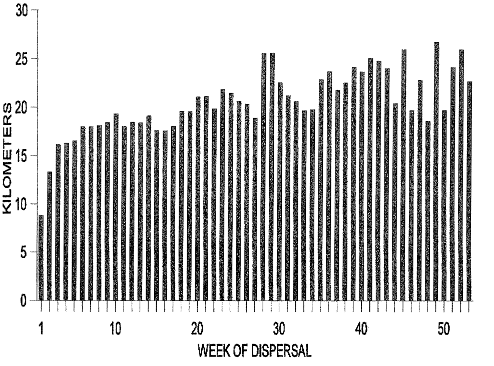


Fig. 5. Average straight-line distance between radio-marked juvenile spotted owls and their natal sites during sequential weekly intervals after they began to disperse in Oregon and Washington, 1990–1996.

0.001) and Washington (range of means = 11–29 June, $F_{1,73}$ = 40.28, $P < 0.001$). Because we sometimes did not find owlets until they had been out of the nest for several days, actual mean dates when owlets left the nest were probably several days earlier than our estimates.

Radio-marked juveniles spent an average of 103.7±0.986 days in the natal territory after leaving the nest ($n$ = 137, range = 76–147 days). Time spent in the natal area varied between the sexes ($F_{1,129}$ = 6.69, $P$ = 0.011) and among years ($F_{3,129}$ = 6.49, $P < 0.001$), with males staying 5 days longer than females on average.

Of 287 cases where we determined approximate dispersal dates of radio-marked juveniles, 286 occurred in the period 9 August–18 December of the year of birth (Fig. 4). The exception was a male that did not disperse from his natal territory until 24 May of the year following birth (this outlier was excluded from estimates of sample means). The estimated mean date that owlets began to disperse was 19 September in Oregon (95% CI = 17–21 September) and 30 September in Washington (95% CI = 25 September–4 October)(Fig. 4). Mean dispersal dates did not differ between males and females ($F_{1,134}$ = 2.26, $P$ = 0.14) or among years ($F_{3,134}$ = 1.17, $P$ = 0.33). Although we did not continuously monitor juveniles during the days immediately before dispersal started, we never saw any parental aggression towards juveniles on those occasions when we visited natal areas to check on radio-marked owls. Rather, it appeared that the adults simply stopped feeding and associating with their young in late August or September, several weeks before dispersal began.

Dispersal of radio-marked juveniles was highly variable, but was typically initiated with a series of rapid movements away from the natal site during the first few days or weeks of dispersal. On average, the straight-line distance between dispersers and their natal sites (DNEST) increased to 8.8 km during the first week of dispersal, 13.3 km during the second week of dispersal, and 16.2 km during the third week of dispersal (Fig. 5). The rapid movements that took place during the first few days or weeks of dispersal were indicated by high average daily rates of movement during September–October (Fig. 6). After the initial pulse of rapid dispersal, most juveniles settled into temporary home ranges in late October or November and remained there for several months. During this period mean daily rates of movement were comparatively low (Fig. 6), and mean DNEST stabilized at about 18–20 km (weeks 10–20 in Fig. 5). Then, in February–May, average daily rates of movement increased

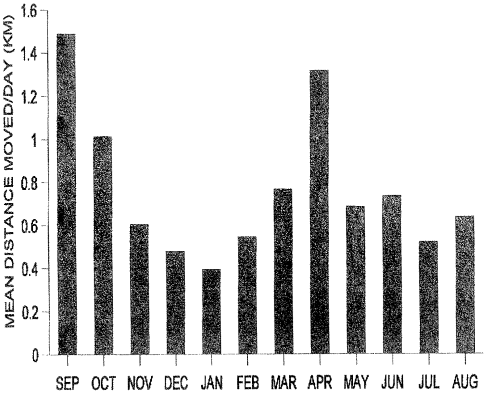


Fig. 6. Average distance moved per day by radio-marked juvenile spotted owls after they started to disperse in Oregon and Washington, 1990–1996. Data are subdivided by monthly intervals.

again (Fig. 6), and many owls moved to new areas, often dispersing considerable distances before settling in their second summer. The direction of this second pulse of natal dispersal was somewhat random relative to the natal site, and as a result, average DNEST leveled off at about 22 km after week 20 (Fig. 5).

Subsequent dispersal patterns were highly variable, with some owls settling permanently in their second summer and others occupying a series of temporary home ranges before eventually settling on territories when they were 2–5 years old (Fig. 7). Occupancy of temporary ranges was punctuated by occasional forays into adjacent areas. In some cases, these forays involved a return visit to areas near the natal site or to a temporary home range occupied during a previous period (Fig. 7). None of the banded or radio-marked juveniles settled at their natal sites, although 6.3% did settle on territories adjacent to their natal sites (males = 7.2%, females = 4.9%).

Areas traversed by dispersing juveniles typically encompassed the home ranges of multiple pairs of resident owls (Fig. 8). However, 85% of the relocations of radio-marked floaters in our Roseburg study area were > 1.5 km from the center of territories occupied by resident pairs, suggesting a strategy in which floaters inhab-

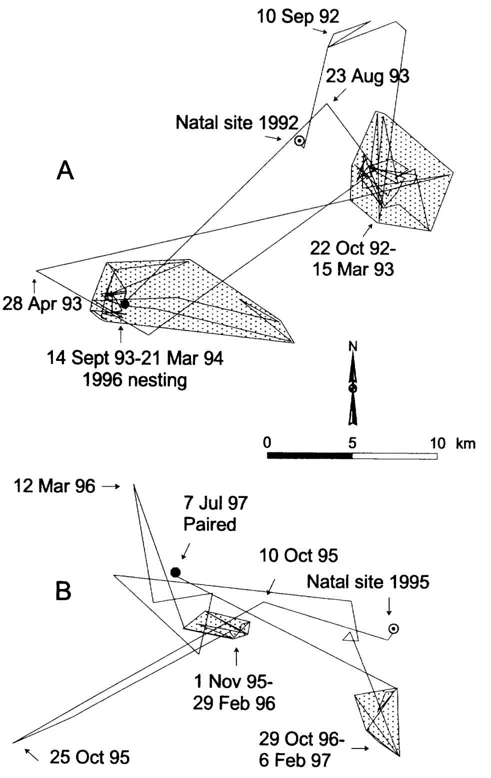


Fig. 7. Examples of movements of 2 radio-marked juvenile spotted owls during natal dispersal in Oregon. Sequential relocations are connected by straight lines. Shaded areas indicate temporary or permanent home ranges occupied by the owls.

ited the periphery of the territories of resident owls, making occasional forays into the territories to test the residents. In a few cases, we found floaters roosting within a few meters of resident pairs. We observed no cases where the floaters that associated with resident pairs were offspring of those pairs and we saw no evidence that they mated with the resident owls. Floaters did not appear to vocalize a great deal, but we did occasionally hear unsolicited vocalizations from them. In a small sample of cases where we used an acoustic lure to see if radio-marked floaters would respond to conspecific calls, we found that males responded 47% of the time ($n$ = 10 males, 19 surveys) and females responded 12% of the time ($n$ = 5 females, 8 surveys).

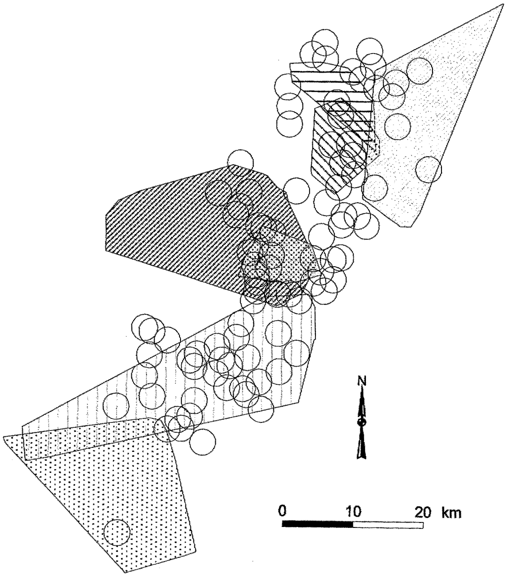


Fig. 8. Areas traversed by spotted owls during natal dispersal in the Roseburg Study Area, Oregon, 1995–1996. Minimum convex polygons indicate areas traversed by individual owls. Circles (2.4 km radius) indicate approximate home range areas of resident pairs, centered on nest trees.

## Natal Dispersal Distance

All regressions of distance dispersed (FIND) on the number of days that owls were radio-tracked produced low $r^2$ values (0.005–0.083), indicating that little of the variation in dispersal distance was explained by the length of the tracking period. As a result, we pooled all data for estimates of mean and median dispersal distances, the only limitation being that owls had to be tracked for ≥ 30 days after initiating dispersal. We also pooled the data for analysis regardless of whether juveniles successfully reproduced after dispersing, because there was no difference in dispersal distance (FIND) of banded owls that successfully reproduced in the year of first recapture and those that did not (♂♂ $F_{1,312} = 1.272$, $P = 0.260$; ♀♀ $F_{1,290} = 0.006$, $P = 0.937$). As a result we did not complicate the analysis by differentiating between owls that dispersed and reproduced (genetic dispersal) and owls that dispersed but did not reproduce (ecological dispersal)(Johnson and Gaines (1990).

Maximum dispersal distances (MAXD) ranged from 1.3–111.2 km for banded juveniles and from 5.5–122.1 km for radio-marked juveniles (Table 2). Final dispersal distances (FIND) ranged from 0.6–111.2 km for banded juveniles and from 1.8–103.5 km for radio-marked juveniles. Distributions of MAXD and FIND were skewed towards shorter distances, with only 8.7% of individuals dispersing more than 50 km (Fig. 9). Because of the skewed distribution, median estimates of MAXD and FIND were consistently lower than means (Table 2).

On average, females dispersed farther than males, regardless of whether we ex-

Table 2. Maximum (MAXD), final (FIND) and effective (EDD) dispersal distances of juvenile spotted owls in Washington and Oregon, 1985–1996.[a]

| | *n* | $\bar{x}$ (km) | SE | Median | Range | EDD |
|---|---|---|---|---|---|---|
| Males | | | | | | |
| MAXD banded | 376 | 20.0 | 0.83 | 15.1 | 1.4–111.2 | 4.3 |
| MAXD radio-marked | 114 | 23.4 | 1.47 | 20.5 | 5.9–94.3 | 5.9 |
| FIND banded | 376 | 19.5 | 0.83 | 14.6 | 0.6–111.2 | 4.2 |
| FIND radio-marked | 114 | 18.1 | 1.47 | 13.5 | 2.7–93.1 | 3.9 |
| Females | | | | | | |
| MAXD banded | 328 | 28.9 | 0.99 | 24.6 | 1.3–104.7 | 7.0 |
| MAXD radio-marked | 122 | 32.2 | 1.71 | 27.7 | 5.5–122.1 | 7.9 |
| FIND banded | 328 | 28.6 | 0.99 | 24.5 | 1.3–104.6 | 7.0 |
| FIND radio-marked | 122 | 26.3 | 1.57 | 22.9 | 1.8–103.5 | 6.5 |

[a] MAXD = straight-line distance to the location farthest from the natal site. FIND = straight-line distance from the natal site to the final location where the owl settled, died, or disappeared. Effective dispersal distance (EDD) was the median dispersal distance divided by the average distance between territories of resident owls (3.5 km).

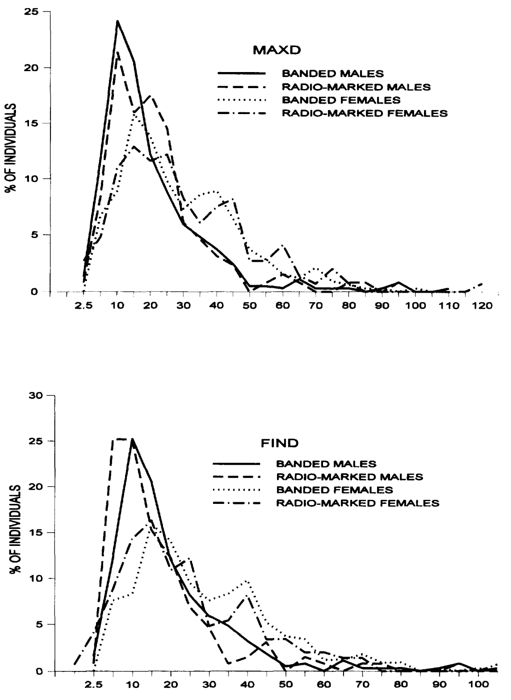


Fig. 9. Distribution of natal dispersal distances of spotted owls in Oregon and Washington, 1985–1996. Maximum (MAXD) and final (FIND) dispersal distances were straight-line distances (km) from the natal site to the farthest and final locations where owls were relocated, respectively.

amined banded owls (FIND $F_{1,703}$ = 64.965, $P < 0.001$; MAXD $F_{1,934}$ = 74.865, $P < 0.001$) or radio-marked owls (FIND $F_{1,234}$ = 18.976, $P < 0.001$; MAXD $F_{1,234}$ = 14.586, $P < 0.001$) (Table 2, Fig. 9). In the sample of banded juveniles, mean and median estimates of FIND for females were 47% and 68% greater than for males, respectively (Table 2). In the sample of radio-marked juveniles, estimates of mean and median FIND for females were 46% and 70% greater than for males, respectively (Table 2).

Estimates of mean FIND were similar for banded and radio-marked owls ($F_{1,947}$ = 1.777, $P$ = 0.183) (Table 2). Estimates of mean MAXD were greater for radio-marked owls than for banded owls ($F_{1,947}$ = 14.381, $P < 0.001$)(Table 2), but this was expected given that we rarely relocated banded juveniles until they settled on a territory. In contrast, we were often able

Table 3. Mean natal dispersal distances (km) of banded spotted owls, subdivided based on age (in years) when owls first nested. This analysis was limited to owls that were first captured when they were ≤ 4 years old, Oregon and Washington, 1985–1996.

| Age when owls first nested | Males | | | Females | | |
|---|---|---|---|---|---|---|
| | $n$ | $\bar{x}$ | SE | $n$ | $\bar{x}$ | SE |
| 1 | 4 | 20.1 | 4.15 | 6 | 22.2 | 5.88 |
| 2 | 25 | 14.9 | 1.81 | 33 | 31.0 | 3.08 |
| 3 | 23 | 17.7 | 2.91 | 20 | 20.9 | 3.00 |
| 4 | 40 | 16.7 | 1.75 | 17 | 28.4 | 4.25 |
| 5 | 11 | 16.7 | 3.74 | 12 | 30.9 | 5.41 |
| 6+ | 13 | 17.5 | 4.02 | 8 | 29.9 | 7.08 |
| Did not nest[a] | 51 | 22.4 | 2.48 | 39 | 30.2 | 2.82 |

[a] Included any owls that dispersed and then did not nest before they disappeared.

to record locations of radio-marked owls at locations beyond where they eventually settled. Thus, comparisons of MAXD obtained with the 2 different methods were useful only to demonstrate that estimates from banding data underestimate maximum dispersal distances. The age when banded owls first nested did not appear to be influenced by dispersal distance for either males ($F_{6,160}$ = 1.129, $P$ = 0.348) or females ($F_{6,128}$ = 1.0113, $P$ = 0.421)(Table 3).

Estimates of effective dispersal distance were similar for banded and radio-marked juveniles (Table 2). The average effective dispersal distance for the pooled samples of radio-marked and banded owls was 4.1 for males, and 6.8 for females.

## Direction of Natal Dispersal

Mean dispersal vectors (FINAZ) differed from random for banded juveniles ($\bar{x}$ = 262, $s$ = 76°, 95% CI = 192–332°, $r$ = 0.121, $\chi^2$ = 21.72, $P$ = 0.001, $n$ = 711) and radio-marked juveniles ($\bar{x}$ = 115°, $s$ = 77°, 95% CI = 38–192°, $r$ = 0.088, $\chi^2$ = 4.96, $P$ = 0.010, $n$ = 324) (Fig. 10). However, the small $r$-values, large mean angular deviations, and large 95% CI's for both samples led us to conclude that statistical differences were due to large sample size as opposed to biologically significant variation (Fig. 10).

The mean difference between final dispersal azimuths of siblings did not differ

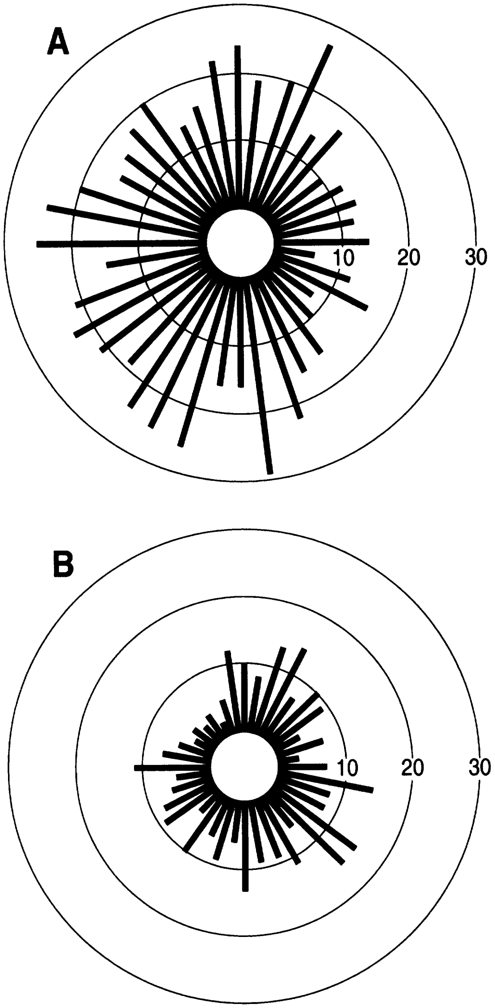


Fig. 10. Distribution of final dispersal azimuths of 1,035 juvenile spotted owls that were banded (A)($n$ = 711) or radio-marked (B)($n$ = 324) in Oregon and Washington, 1985–1996. Columns indicate number of owls dispersing in each 9° arc.

from 90° ($\bar{x}$ = 84.131±4.555°, $t_{144}$ = 1.318, $P$ = 0.095, $n$ = 145 paired samples). This suggested that dispersal azimuths of siblings were not correlated. In addition, siblings were never found together while dispersing, indicating that they dispersed independently.

## Social Integration of Juveniles

*Age at Recruitment.*—Of the radio-marked owls that were alive, 21.5% of males and 44.2% of females were paired at age 1, and 67.6% of males and 76.9% of females were paired at age 2 (Table 4). We considered these estimates as analogous to recruitment rates, because most radio-marked owls that were single at 1–2 years of age were unsettled itinerants. Estimates from the radio-marked sample suggested that considerably more females than males were recruited into the territorial population at age 1, and that sexual differences in recruitment began to even out after year 1. Few of the radio-marked owls that were paired nested at 1–2 years of age (Table 4).

Estimates of recruitment rates of banded owls based on age at first recapture (age = 1, 2, 3, 4, or >4) were 33%, 31%, 17%, 10%, and 9%, respectively. Comparable estimates of recruitment from the radio-marked sample were 33% for 1-year-old owls and 39% for 2-year-old owls. The latter estimate was derived by subtracting the proportion of owls that were paired in year 1 from the proportion of owls paired in year 2 (Table 4). Assuming that banded owls were recruited into the territorial population when they were first recaptured, mean age at recruitment was 2.36±0.07 years for males (range = 1–8, 95% CI = 2.22–2.49, $n$ = 375) and 2.39±0.08 years for females (range = 1–8 years, 95% CI = 2.23–2.55, $n$ = 327).

Although mean estimates of recruitment from the banded and radio-marked samples were similar, the 2 methods produced very different estimates of sexual differences in recruitment and of social status of recruits. Whereas the radio-marked sample indicated that nearly twice as many females as males were recruited at 1 year of age (Table 4), the banded sample indicated that percentages of banded owls first recaptured in different age cohorts did not differ between males and females ($\chi^2_4$ = 6.35, $P$ = 0.175). In addition, the social distribution of owls in the 2 samples was different (Table 4). In the banded sample, most males and over 90% of females were paired when they were first recaptured at 1–2 years of age (Table 4). In the radio-marked sample, most owls were single at

Table 4. Social status of known-age spotted owls detected in study areas in Oregon and Washington, 1985–1996. Data are expressed as the percentage of total individuals recaptured or resighted in each age class. The sample for each age cohort included all owls detected, regardless of whether the same owls were also detected in other age cohorts.

| | Radio-marked owls[a] | | Banded owls[b] | | |
|---|---|---|---|---|---|
| | Age = 1 | Age = 2 | Age = 1 | Age = 2 | Age = 3+ |
| Males | | | | | |
| Single | 78.5 | 32.4 | 37.4 | 23.2 | 15.1 |
| Paired, not breeding | 20.0 | 62.2 | 56.9 | 57.2 | 50.8 |
| Paired, breeding | 1.5 | 5.4 | 5.7 | 19.6 | 34.1 |
| Females | | | | | |
| Single | 55.8 | 23.1 | 8.4 | 6.0 | 5.7 |
| Paired, not breeding | 42.6 | 74.3 | 83.2 | 60.7 | 54.8 |
| Paired, breeding | 1.6 | 2.6 | 8.4 | 33.3 | 39.5 |

[a] Sample sizes were: age 1 year = 65 ♂♂, 61 ♀♀; age 2 years = 37 ♂♂, 39 ♀♀.
[b] Sample sizes were: age 1 year = 123 ♂♂, 107 ♀♀; age 2 years = 138 ♂♂, 117 ♀♀; age 3+ years = 464 ♂♂, 403 ♀♀.

1 year of age, and 23% of females and 32% of males were still single at 2 years of age (Table 4).

*Inbreeding.*—Despite monitoring thousands of pairs of spotted owls for periods ranging from 5–13 years, we documented only 3 cases of close inbreeding, including a half-sib pair (same father), a full-sib pair, and a father-daughter pair. The half-siblings were produced on the same territory and settled 2.2 km away, where they produced 2 young in 2 different years. The full-sib pair consisted of offspring from the 1990 cohort. They nested and produced 2 young in 1992, 4.4 km from their natal site. The female disappeared after 1992. The father-daughter pair was a case where an adult male dispersed 3.5 km and paired with his 2-year-old daughter from his previous territory. They nested in 3 of the 4 years they were together, but produced only 1 young. Although inbreeding between siblings or parents and offspring was a rare event, pairings between dispersers and more distant relatives (cousins, aunts, uncles, grandparents, or great grandparents was common (Reid and Forsman, unpublished data).

## Causes of Mortality

Of the 386 juveniles that we radio-marked, at least 188 (48.7%) died before or during dispersal. In 122 cases where we were able to infer cause of death from signs found at the recovery site, 83 owls (68.0%) died from predation, 32 (26.2%) starved and 7 (5.7%) died from accidents. Of the 83 cases of predation, 67 (81%) were due to avian predators, and 16 (19%) were due to predation by mammals or unknown predators. In most of the latter cases, it was unclear whether owls were killed by predators or were scavenged after the were already dead or dying from starvation or disease. Thus, if anything, we suspect that mortality from starvation is underestimated by our analysis, whereas death from predation is probably slightly overestimated.

We suspected that great horned owls (*Bubo virginianus*) were responsible for most cases of avian predation, but we could only confirm this in 1 case where we found a transmitter in a great horned owl nest and 2 cases where we found remains in great horned owl pellets. The most common cause of accidents was collisions with vehicles (n = 4), but we also documented 1 case where an owl caught its wing in a narrow crevice in a tree trunk, 1 case where an owl impaled itself on a sharp stick, and 1 case where an owl was apparently killed by a falling tree in an area that was being logged.

Although starvation and predation appeared to be the ultimate cause of death in 94% of cases, parasites or disease may have been a predisposing factor in some cases. Of 48 juvenile and adult owls that we recovered intact enough for at least a

Table 5. Annual estimates of the percentage of banded non-juvenile spotted owls that dispersed to new territories (Disp.), remained on the same territory (Stayed) or disappeared and were never seen again (Gone) on study areas in Oregon and Washington, 1985–1996.[a]

| | 1-year-old owls | | | 2-year-old owls | | | ≥ 3-year-old owls | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Gone | Stayed | Disp. | Gone | Stayed | Disp. | Gone | Stayed | Disp. |
| 86 | | | | | | | 17 | 78 | 4 |
| 87 | | | | | | | 16 | 78 | 6 |
| 88 | 20 | 55 | 25 | 8 | 92 | 0 | 14 | 83 | 3 |
| 89 | 38 | 56 | 6 | 11 | 69 | 20 | 26 | 71 | 3 |
| 90 | 35 | 45 | 20 | 19 | 70 | 11 | 16 | 77 | 7 |
| 91 | 36 | 50 | 14 | 14 | 71 | 16 | 16 | 78 | 6 |
| 92 | 39 | 46 | 15 | 11 | 66 | 23 | 15 | 79 | 6 |
| 93 | 30 | 32 | 39 | 18 | 68 | 14 | 23 | 71 | 6 |
| 94 | 29 | 52 | 19 | 19 | 71 | 10 | 13 | 82 | 5 |
| 95 | 30 | 45 | 25 | 23 | 57 | 20 | 20 | 76 | 4 |
| 96 | 33 | 46 | 21 | 28 | 61 | 11 | 16 | 79 | 5 |
| $\bar{x}$ | 32 | 48 | 20 | 17 | 69 | 14 | 17 | 78 | 5 |

[a] Sample sizes by year for each age class were: 1 year old (20, 16, 20, 36, 39, 44, 48, 20, 33); 2 years old (12, 45, 27, 51, 53, 57, 48, 91, 18); ≥ 3 years old (52, 107, 220, 296, 411, 697, 773, 886, 839, 841, 820).

partial necropsy, at least 32 (67%) were infected by blood parasites or intestinal parasites, or had evidence of disease. Infections with multiple species of hemoparasites and intestinal parasites were common, and 1 owl had avian cholera.

## Breeding Dispersal

*Proportion of non-juveniles dispersing per year.*—Of the non-juvenile owls that we banded, 6.6% dispersed each year, and 18% disappeared each year and were never seen again. The annual proportion of owls that dispersed was highest for 1-year-old owls ($\bar{x}$ = 20%, 95% CI = 13.6–27.4%), intermediate for 2-year-old owls ($\bar{x}$ = 14%, 95% CI = 8.6–19.1%), and lowest for owls that were ≥ 3 years old ($\bar{x}$ = 5.0%, 95% CI = 4.0–6.1%)($F_{2,24}$ = 12.61, $P$ <0.001) (Table 5). The proportion of owls that dispersed did not vary among years for the combined sample ($\chi^2_{10}$ = 8.9, $P$ = 0.54) or for any age groups ($\chi^2$ $P$-values ranged from 0.156–0.48). When owls that were ≥ 3-years old were subdivided into minimum age classes based on length of tenure in our studies, annual rates of dispersal differed among age classes (Table 6, $F_{9,6,422}$ = 6.185, $P$ < 0.001). However, this relationship was not evident when the 2 youngest minimum age classes (3–4) were removed from the analysis ($F_{7,3,406}$ = 0.304, P = 0.952). This suggested that annual dispersal rates of older adults (minimum age = 5–12 years) did not differ among age classes (Table 6).

Table 6. Minimum percentage of banded adult northern spotted owls that dispersed each year in study areas in Oregon and Washington, subdivided by minimum age class, 1985–1996. Minimum age class indicates minimum age of owls in the previous breeding season.

| Minimum age (years) | $n$ | % dispersing | 95% CI |
|---|---|---|---|
| 3 | 1,709 | 8.31 | 7.00–9.62 |
| 4 | 1,309 | 5.19 | 3.99–6.40 |
| 5 | 1,042 | 4.13 | 2.92–5.34 |
| 6 | 820 | 3.29 | 2.07–4.52 |
| 7 | 620 | 3.23 | 1.83–4.62 |
| 8 | 445 | 3.60 | 1.86–5.33 |
| 9 | 266 | 2.63 | 0.70–4.57 |
| 10 | 130 | 3.08 | 0.07–6.09 |
| 11 | 60 | 3.33 | 0.00–8.00 |
| 12 | 31 | 3.23 | 0.00–0.98 |

We observed only 1 dispersal event for most (83%) of the banded owls that undertook breeding dispersal (363 of 440 owls). In 39 cases (9%) where owls that were ≥ 3 years old dispersed twice, 41% moved back to their previous territory on the second move. Owls that were banded at 1 or 2 years of age, and then moved twice, returned to their original territory on the second move only 11% and 24% of the time, respectively. Of 12 owls that

Table 7. Annual percentage of banded non-juvenile spotted owls that dispersed to new territories, stayed on the same territories, or disappeared and were never seen again, relative to the status of the mate from the previous year. $\chi^2$ results are for tests of the null hypothesis that proportions did not differ among age groups.

| Status of previous mate[a] | Age in years | Percentage of owls | | | $n$ | $\chi^2$ | $P$ |
|---|---|---|---|---|---|---|---|
| | | Dispersed | Stayed | Disappeared | | | |
| Dispersed | 1 | 31 | 19 | 50 | 16 | 5.5 | 0.240 |
| | 2 | 44 | 36 | 20 | 25 | | |
| | 3+ | 29 | 31 | 40 | 237 | | |
| Stayed | 1 | 9 | 71 | 20 | 123 | 53.4 | <0.001 |
| | 2 | 4 | 84 | 12 | 262 | | |
| | 3+ | 1 | 87 | 12 | 4,855 | | |
| Gone | 1 | 28 | 26 | 46 | 35 | 29.7 | <0.001 |
| | 2 | 21 | 44 | 35 | 72 | | |
| | 3+ | 10 | 60 | 30 | 921 | | |
| No mate | 1 | 35 | 28 | 37 | 89 | 39.6 | <0.001 |
| | 2 | 41 | 45 | 14 | 56 | | |
| | 3+ | 18 | 58 | 24 | 388 | | |

[a] "Dispersed" = old mate moved to a new territory, "Stayed" = old mate still present at old territory, "Gone" = old mate disappeared and never seen again, "No mate" = owl did not have a mate in previous year.

were ≥ 3 years old that moved 3–4 times, 6 moved to a different territory every time, 3 moved back and forth between 2 adjacent territories, 1 moved once and then moved back and forth between 2 adjacent territories, and 2 moved back and forth between 2 territories before moving to a third territory.

*Factors Associated With Breeding Dispersal.*—Annual dispersal rates were higher for owls whose mates disappeared or moved to another territory than for owls whose mates were still present on the historic territory (Table 7). On average, dispersal rates of females were slightly higher than males, but the differences were significant in only 2 of 11 years examined (Table 8).

Ten percent of breeding dispersal events by owls that were ≥ 3 years old involved cases where both members of a pair moved together to an adjacent territory, 10% involved cases where pairs split up and moved to new locations, and 17.5% involved cases where an owl dispersed while its mate stayed at the original territory (Table 9). Of 118 cases where adult pairs split up, 57% appeared to be divorces, as evidenced by the fact that the previous mate was single in the year following the breakup, or was paired with a new mate on a new territory. In the other 43% of cases it was unclear if dispersal was the result of a divorce or eviction by a competitor, since the owl that moved was immediately replaced on its old territory (Table 9).

The logistic regression analysis of breeding dispersal indicated that the likelihood of dispersal in a given year was simultaneously influenced by sex, age and social factors (SF), in the following manner:

$$\begin{aligned}\log(\text{odds of dispersal}) &= -3.705 - 0.711{*}\mathrm{SEX} + 3.069{*}\mathrm{SF}_1 \\ &\quad + 2.275{*}\mathrm{SF}_2 + 3.983{*}\mathrm{SF}_3 \\ &\quad + 1.573{*}\mathrm{AGE}_1 + 0.9468{*}\mathrm{AGE}_2\end{aligned}$$

where $\mathrm{SF}_1 = 1$ if the owl was single in the previous year, $\mathrm{SF}_2 = 1$ if the mate from the previous year was missing or dead, $\mathrm{SF}_3 = 1$ if the mate from previous year moved to a new territory, and $\mathrm{AGE}_1 = 1$ if age in the previous year was 1, and $\mathrm{AGE}_2 = 1$ if age in the previous year was 2. (Table 10). Other factors being equal (i.e., same sex and social factor), the probability of movement was greatest for 1-year-old owls, intermediate for 2-year-old owls and lowest for owls that were ≥3 years old (Table 10). Females were 1.6–2.6 times more likely to move than males, other factors being equal (Table 10). Owls that were single in the previous year or whose mates from the previous year disappeared or moved to a

Table 8. Minimum percentage of adult spotted owls (≥ 3 years old) that dispersed each year on study areas in Oregon and Washington, 1985–1996, subdivided by sex.[a]

| Year | $n$ | Percent of owls dispersing | | $\chi^2$ | $P$ |
|---|---|---|---|---|---|
| | ♂♂:♀♀ | ♂♂ | ♀♀ | | |
| 1986 | 28:24 | 3.6 | 4.2 | 0.01 | 0.91 |
| 1987 | 64:43 | 1.6 | 14.0 | 6.46 | 0.01 |
| 1988 | 123:97 | 1.6 | 4.1 | 1.27 | 0.26 |
| 1989 | 163:133 | 2.5 | 4.5 | 0.95 | 0.33 |
| 1990 | 222:189 | 6.8 | 7.4 | 0.07 | 0.78 |
| 1991 | 374:305 | 4.5 | 8.2 | 3.86 | 0.05 |
| 1992 | 429:353 | 6.7 | 4.8 | 1.20 | 0.27 |
| 1993 | 468:418 | 5.8 | 5.5 | 0.03 | 0.86 |
| 1994 | 441:398 | 5.7 | 4.3 | 0.86 | 0.35 |
| 1995 | 435:406 | 4.4 | 3.9 | 0.10 | 0.76 |
| 1996 | 430:390 | 4.9 | 5.4 | 0.11 | 0.74 |
| $\bar{x}$ | | 4.4 | 6.0 | | |

[a] Data combined from the Cle Elum, Siuslaw, Roseburg, H. J. Andrews, Coos, Eugene, and Salem Study Areas. Owls present at the same site or missing and never seen again were counted as non-dispersers.

new site were much more likely to disperse than owls whose mates from the previous year were still present at the same territory (Table 10). The highest odds of movement were for owls whose mates moved to a new territory. In those cases, owls were 36–80 times more likely to move than owls whose mates were still present on the same territory (Table 10).

The selected logistic regression model from the analysis of dispersal relative to sex, age, and breeding status in the previous year (PNS) was:

$$\begin{aligned}\log(\text{odds of dispersal}) &= -3.0192 - 0.6848*\text{SEX}♂ \\ &\quad + 1.7090*\text{AGE}_1 + 1.0735*\text{AGE}_2 \\ &\quad + 0.5524*\text{PNS} \\ &\quad + 0.6673*\text{SEX}♂*\text{PNS}\end{aligned}$$

where PNS = 1 if the owl did not nest in the previous year, or 0 otherwise. This model also included an interaction with sex and previous nesting status, indicating that the effect of previous nesting status differed between the sexes. Males that did not nest in the previous year were 2.6–4.3 times more likely to move than males that nested in the previous year, whereas females that did not nest in the previous year were 1.2–2.4 times more likely to move than females that nested in the previous year.

*Distance and direction of Breeding Dispersal.*—Mean breeding dispersal distances were considerably shorter than distances moved by natal dispersers (Table 11, Fig. 3) and did not differ between the sexes or among study areas (all $P$-values > 0.10). On average, young owls dispersed farther than older owls ($F_{2,435}$ = 3.674, $P$ = 0.026) (Table 11). Mean FIND did not differ depending on the number of times that owls dispersed for any age classes except adults. Adults that moved twice tended to move closer to their original territory

Table 9. Percentage of observed breeding dispersal events of spotted owls relative to the status of the mate from the previous territory in the year that dispersal occurred, Oregon and Washington, 1985–1996. Estimates are presented separately for owls that dispersed when they were 1, 2, or ≥ 3 years old.

| Status of mate from previous territory | Percentage of dispersal events | | |
|---|---|---|---|
| | Age 1 | Age 2 | Age ≥ 3 |
| Owl did not have a mate at previous territory | 51.4 | 34.2 | 16.8 |
| Previous mate died (confirmed death) | 1.4 | 1.0 | 2.8 |
| Previous mate missing and never seen again | 13.5 | 31.3 | 38.5 |
| Pair moved to new territory together | | 5.1 | 10.0 |
| Previous mate single at previous territory | 6.6 | 1.0 | 5.6 |
| Previous mate single at a new territory | 2.7 | 1.0 | 1.4 |
| Previous mate paired with new mate at same territory | 12.2 | 16.2 | 11.9 |
| Previous mate paired with new mate at new territory | 9.5 | 6.1 | 8.6 |
| Previous mate missing, but seen in later years | 2.7 | 4.1 | 4.4 |
| Total | 100.0 | 100.0 | 100.0 |

[a] Sample sizes by age group were 72, 99, 429

Table 10. Relative odds of breeding dispersal of spotted owls in Oregon and Washington in 1985–1996, based on the selected logistic regression model. In each row the 95% CI's indicate the relative odds (or likelihood) that owls with characteristics indicated under group 1 will disperse, compared to owls with characteristics indicated under group 2. The SF column indicates the status of the mate from the previous territory in the year that dispersal occurred (D = disappeared or presumed dead, M = moved to new territory, P = still present at old territory, S = the owl that dispersed did not have a mate in the year prior to dispersal). A blank variable in a row means that both groups have the same status for that variable. The table displays only a few of many possible comparisons.

| Group 1 | | | Group 2 | | | 95% CI on relative odds of dispersal (group 1 versus group 2) |
|---|---|---|---|---|---|---|
| Sex | Age[a] | SF | Sex | Age | SF | |
| ♀ | | | ♂ | | | 1.6–2.6 greater |
| | 1 | | | 3+ | | 3.2–7.3 greater |
| | 2 | | | 3+ | | 1.8–3.7 greater |
| | | S | | | P | 15.2–30.4 greater |
| | | D | | | P | 7.1–13.3 greater |
| | | M | | | P | 35.9–80.3 greater |
| | 1 | S | | 3+ | P | 62.0–174.2 greater |
| ♀ | 1 | S | ♂ | 3+ | P | 156.6–283.2 greater |
| ♀ | 1 | M | ♂ | 3+ | P | 378.8–732.9 greater |

[a] Age = 1, 2, or ≥ 3 years old.

if they moved twice ($F_{2,291}$ = 23.09, $P$ <0.001). That is, they tended to move back to their original territory after occupying an adjacent territory for 1 or more years. The direction of post-natal dispersal did not differ from random regardless of whether we examined the azimuth from the origin to the final location ($\bar{x}$ = 123°, $r$ = 0.011, $\chi^2$ = 0.07, $P$ = 0.97, $n$ = 294) or the azimuth from the origin to the farthest recorded location ($\bar{x}$ = 121°, $r$ = 0.008, $\chi^2$ = 0.03, $P$ = 0.98, $n$ = 294).

## Barriers To Dispersal

The large, non-forested valleys of western Oregon (Willamette, Rogue, and Umpqua Valleys) appeared to act as barriers to dispersal between the Coastal Mountains and Cascades Mountains (Figs. 2–3). For example, we never documented any movements directly across the Willamette Valley, which separates the Oregon Coast Ranges from the Cascades Mountains (Figs. 2–3). However, owls did disperse from the Coastal Mountains to the Cascades Mountains in the broad forested regions between the Willamette, Umpqua and Rogue valleys (Figs. 2–3).

Although large areas of non-forested habitat appeared to inhibit dispersal, spotted owls regularly dispersed through the highly fragmented forest landscapes that were typical of the mountain ranges in western Oregon and Washington. They also crossed highway corridors such as Interstate 5 in Oregon and Interstate 90 in Washington. Although dispersal typically occurred in fragmented forest landscapes, an analysis of the survival of dispersing owls relative to the degree of forest fragmentation was beyond the scope of our study.

We observed several owls that crossed the crest of the Cascades Mountains, dispersing through high-elevation areas of mixed subalpine forest and alpine tundra. The relative infrequency of these movements suggested that high elevation areas dominated by mixtures of subalpine forest and alpine tundra inhibited dispersal, but did not completely stop it.

Owls regularly dispersed around or over lakes and rivers, except in the case of very wide bodies of water. The most notable example was the large marine inlets (Hood

Table 11. Breeding dispersal distances of banded non-juvenile spotted owls that moved from 1 territory to another in Oregon or Washington, 1985–1996.

| Age of owl in years | Distance moved (km) | | | | |
|---|---|---|---|---|---|
| | $\bar{x}$ | SE | Median | Range | $n$ |
| 1 | 8.2 | 1.21 | 5.1 | 0.01–63.7 | 71 |
| 2 | 6.9 | 0.93 | 4.1 | 0.17–50.7 | 75 |
| 3+ | 6.1 | 0.49 | 3.5 | 0.01–85.2 | 294 |

Canal and Puget Sound) that separated the Olympic Peninsula from mainland Washington (Figs. 3–4). We did not document any dispersal from the peninsula across Hood Canal or Puget Sound. We also did not observe any dispersal between the peninsula and southwestern Washington (Figs. 3–4). While the absence of recorded dispersal movements between the peninsula and southwestern Washington or the Washington Cascades may indicate that the owl population on the peninsula is relatively isolated, it could also be due to the fact that there were no demography studies of spotted owls in areas immediately adjacent to the peninsula, and thus little chance of detecting dispersal.

## DISCUSSION

### Natal Dispersal

Although the behavior of dispersing juveniles was highly variable, the most common pattern in our study and in all previous studies of dispersal in the spotted owl was for juveniles to move rapidly away from the natal site during September–November (Gutiérrez et al. 1985, Miller 1989, Arsenault et al. 1997, Ganey et al. 1998). Both sexes dispersed, and we never saw any cases where juveniles settled on their natal sites. After the initial surge of movement away from the natal site most individuals settled in 1 or more temporary home ranges before eventually acquiring territories. This pattern of dispersal seems to be fairly typical of non-migratory owls (Korpimäki and Lagerström 1988, Belthoff and Ritchison 1989, Bull and Henjum 1990, Taylor 1994, Ellsworth and Belthoff 1997, Rhoner 1997*a, b*).

Our estimates of the amount of mean time spent in the natal area prior to dispersal (103 days) and mean dates of dispersal (19–30 Sept.) are similar to estimates from previous studies (Miller 1989, Ganey et al. 1998), suggesting that these parameters do not vary much, even between populations in widely disparate areas. However, some yearly variation may occur (this study, Ganey et al. 1998). Great horned owls are similar to spotted owls in that their young disperse primarily in September or October after spending several months at their birth site (Rhoner 1997*b*). In comparison, the young of some other owls spend comparatively little time at the natal site before dispersing. For example, the mean interval between fledging and initiation of dispersal was $55 \pm 1.3$ days for eastern screech owls (*Otus asio*) and $60 \pm 2.4$ days for western screech owls (*O. kennicottii*) (Ellsworth and Belthoff 1997: 156, Belthoff and Ritchison 1989:256). Barn owls (*Tyto alba*) have a particularly short period of postnatal care, typically dispersing within 2–5 weeks after leaving the nest (Seel et al. 1983, Taylor 1994).

The negatively skewed distribution of dispersal distances observed in our study is typical of natal dispersal in most organisms (Bateman 1950, Stewart 1952, Levin and Kerster 1974, Adamcik and Keith 1978, Greenwood 1980, Moore and Dolbeer 1989). A concern in banding studies is that a negatively skewed distribution of dispersal distances can result from survey bias if search effort is focused primarily in a small, finite study area (Barrowclough 1978, Moore and Dolbeer 1989, Koenig et al. 1996). Because our estimates of means and ranges of dispersal distance were similar for banded and radio-marked owls, we concluded that recaptures of banded owls were not influenced by small study area bias. This outcome was not particularly surprising because our study areas were large and because we received assistance from observers outside our study areas who were also conducting surveys of spotted owls.

Although we observed no cases where northern spotted owls dispersed >122 km, there is 1 record of a female Mexican spotted owl (*S. o. lucida*) that was recovered 187 km from her original banding location (Gutiérrez et al. 1996). In addition, we confirmed 1 case of long-distance dispersal that we did not include in our analysis because the bird was an F1 female hybrid between a spotted owl and a northern barred owl (*Strix varia*). This hybrid was banded as a juvenile in 1986 in the south-

ern Cascades of Washington (H. Allen pers. comm), and subsequently dispersed 292 km to the northwest tip of the Olympic Peninsula, where she was recaptured in 1991 and resighted in most years from 1992–2001. We do not know if this exceptionally long dispersal event was an anomaly or is indicative of stronger dispersal by hybrids or barred owls. Regardless, it is clear from our data that dispersal distances >100 km are rare for northern spotted owls.

Although few juveniles tracked in previous studies of spotted owls were monitored long enough to determine where they eventually settled (Allen and Brewer 1985, Gutiérrez et al. 1985, 1996, Laymon 1988, Miller 1989, Verner et al 1992, U.S. Fish and Wildlife Service 1995, Arsenault et al. 1997, Miller et al. 1997, Ganey et al. 1998), mean dispersal distances in those studies were similar to our estimates from owls that were tracked for much longer periods and that eventually settled on territories. We believe this was the case because, after the initial surge of dispersal away from natal sites in September–December, the direction of subsequent movements was essentially random relative to the natal territories. As a result, mean dispersal distances stabilized within 4–6 months after dispersal began, even though many individuals continued to disperse and did not acquire territories until they were several years old. Similarly, Bairlien (1985) found that mean natal dispersal distances of barn owls stabilized after 4–5 months, even though some birds were still dispersing.

Although data from most previous studies of natal dispersal in the spotted owl were not subdivided by sex, small samples from Miller (1989) and Gutiérrez et al. 1996) are in agreement with our results, in that females dispersed farther than males. This same pattern has been reported for many other birds (Greenwood and Harvey 1982), including many birds of prey (Fuiczynski 1978, Newton 1986, Korpimäki 1988, James et al. 1989, Taylor 1994, Dietrich and Woodbridge 1994, Rosenfield and Bielfeldt 1996, Wellicome et al. 1997, Forero et al. 1999, Marti 1999, Real and Manosa 2001). However, there are exceptions (Greenwood and Harvey 1982, Picozzi 1984). Thrailkill et al. (1997) found no sexual differences in dispersal distances of spotted owls, but their samples were very small.

In some birds there is evidence that individuals that disperse farther may settle on lower quality territories or may breed later or have smaller clutches (Newton 1986). We did not examine clutch size or territory quality, but the fact that we found no relationship between dispersal distance and age when owls first nested does not suggest a negative relationship between dispersal distance and lifetime reproduction in the spotted owl. A number of other studies have also found little correlation between reproductive performance and dispersal distance in birds (Greenwood et al. 1979, Marti 1999), and Spear et al. (1998) found that survival and reproduction were positively correlated with natal dispersal distance. Our results suggest that, in long-lived birds like spotted owls, which typically do not breed until they are several years old, dispersal distance has little influence on lifetime reproduction compared to other factors such as annual or local variation in weather (Franklin et al. 2000) or prey abundance (Carey et al. 1992, Ward et al. 1998).

Dispersal distances in owls vary greatly among species. Estimates from barn owls and great horned owls suggest that they disperse farther than spotted owls on average, and that occasional individuals undertake extremely long movements. However, the majority of barn owls and great horned owls do not disperse more than 80 km from their natal sites (Stewart 1952, 1969, Braaksma and de Bruijn 1976, Houston 1978, Adamcik and Keith 1978, Bairlien 1985, Taylor 1994, Marty 1999). Of 434 recoveries of banded great horned owls reported by Stewart (1969:156), 405 (93%) were within 80 km of the natal site. The other 29 recoveries included 16 owls that dispersed more than 160 km, including 1 that dispersed 1,370 km. Thus, it appears that great horned owls and barn

owls, while capable of very long movements, typically settle near their natal sites. Tengmalm's owls (*Aegolius funereus*) also appear to be fairly strong dispersers, often moving long distances in years of low prey abundance (Korpimäki and Lagerström 1988). In contrast, the mean dispersal distance of 31 radio-marked screech owls (*Otus kennicottii*) from the natal site to the location where the owls overwintered was only 10.6±1.8 km (Ellsworth and Belthoff 1997:157). None of the above studies provided estimates of effective dispersal distances, but estimates from several species of small resident birds are similar to spotted owls (Shields 1983).

For specialist vole predators like the Tengmalm's owl, saw-whet owl (*Aegolius acadicus*), snowy owl (*Nyctea scandiaca*) and barn owl, or species that feed on cyclic populations of snowshoe hares, like the great horned owl, the tendency to disperse long distances in some years is probably a response to a highly variable prey resource (Lofgren et al. 1986, Korpimäki 1986, Hayward et al. 1993, Marks 1997, Rhoner 1997*a, b,* Smith 1997). In comparison, spotted owls have a rather diverse diet and their primary prey are not known to undergo large annual variations in abundance (Rosenberg et al. 1992, Ward et al. 1998). As a result, spotted owls are probably rarely faced with the almost complete collapse of their prey supply, and are less likely to exhibit migratory or nomadic behavior than are species with more irruptive or cyclic prey.

## Dispersal Direction

Previous studies of natal dispersal of spotted owls have suggested that the distribution of individual dispersal azimuths is random (Miller 1989, Gutiérrez et al. 1985, Ganey et al. 1998). We also concluded that there was little evidence of a biologically significant trend in dispersal direction, even though our statistical tests on large samples suggested a non-random pattern. With samples as large as ours, even a small divergence from a random distribution can produce a significant result, which led us to question the biological relevance of the test results.

Houston (1978) and Adamcik et al. (1978) concluded that directional orientation of dispersal by great horned owls was random except in poor prey years, when a disproportionate number of juveniles dispersed long distances to the south. Whether this represented permanent dispersal or a southward migration was unclear (Adamcik et al. 1978). Bunn et al. (1982) and Taylor (1994) found that dispersal direction of barn owls in Scotland and Great Britain did not differ from random. In contrast, studies of barn owl dispersal in continental Europe and Utah indicated non-random dispersal, possibly in response to mountain ranges that acted as barriers to dispersal (Taylor 1994, Marti 1999).

Absence of strong or consistent directional tendencies in dispersal based on pooled samples from many different territories in no way implies that direction of dispersal from individual territories is random. Spotted owls in western Washington and Oregon occupy extremely heterogenous environments where the distribution of forest habitat adjacent to individual territories is highly variable. In this situation, it is possible that dispersal direction from individual territories might be a nonrandom response to the local distribution of habitat and topography, whereas the pooled data from many different territories would suggest a random pattern. Thus, it should not be concluded from our results that owls simply move randomly away from the natal site without regard to the distribution of suitable habitat.

Although it is clear from our study that spotted owls disperse across fragmented forest landscapes, we do not know if survival rates of dispersing owls are influenced by the amount of forest fragmentation or the amount of suitable habitat encountered along the dispersal path. Lamberson et al. (1992) suggested that survival of dispersing spotted owls may be lower in fragmented forests or areas with little old forest. However, Miller (1989) found no correlation between forest fragmentation

and survival or dispersal distance of spotted owls. Observations of Mexican spotted owls (*S. o. lucida*) in the southwestern U.S. indicate that they will, at least occasionally, disperse across large areas of inhospitable habitat between isolated mountain ranges (Gutiérrez et al. 1996, Arsenault et al. 1997, Ganey et al. 1998). In an interesting contrast, however, LaHaye et al. (1994) observed no dispersal between insular populations of spotted owls in southern California. Obviously, more work is needed to evaluate the influence of habitat fragmentation and habitat quality on dispersal distance and survival of dispersing spotted owls.

## Social Integration of Dispersers

The fact that most of our radio-marked owls were paired by the time they were 2 years old suggests that the majority of young spotted owls are integrated into the territorial population relatively quickly, but some (about 23% of females and 32% of males) do not acquire territories until they are ≥3 years old. Although they often form somewhat tenuous pair bonds and defend territories, spotted owls that are 1–2 years old rarely breed (this study, Miller et al. 1985, Burnham et al. 1996). It is unclear whether this is due to physiological immaturity, lack of experience, or both.

In our study, integration of young owls into the territorial population closely paralleled Franklin (1992). He estimated that mean age of recruitment into the territorial population was 1.9±0.3 years ($n$ = 16), compared to 2.4 years in our study. He also estimated that 40% of males did not enter the territorial population until they were >2 years old (32% in our study). The main difference between his study and ours was that he reported all females were integrated into the territorial population by the time they were 2 years old. In contrast, we found that 23% of radio-marked females were still unpaired floaters when they were 2 years old, and did not enter the territorial population until they were 3–5 years old.

Some studies of owls and diurnal raptors suggest that more females than males breed at 1–2 years of age (Newton 1979, Rhoner 1987*a*). Although our data from radio-marked owls indicated that a higher proportion of females than males were recruited into the territorial population as 1-year-olds, proportions of males and females that actually bred at 1 year of age were essentially identical, and more males nested at 2 years of age than did females. In contrast, our data from banded owls indicated no sexual differences in recruitment rates of males and females for any age classes, and proportions of females breeding at age 1 or 2 were higher than males. The difference between our results from radio-marked owls and banded owls may have been due to a sampling bias in the data from banded owls. Female spotted owls that are not radio-marked tend to be more difficult to locate than males unless they are paired or breeding, in which case they are often located by following the male to the female (Reid et al. 1999). Given this bias it is not surprising that samples based on recaptures of banded owls should include fewer single females and more females that are paired or breeding, compared to males. We do not know if this bias is unique to spotted owls or is a problem in studies of other species, as well.

In our study, the proportion of radio-marked owls that were paired or breeding at 1 year of age was much lower than in the sample of banded owls, regardless of sex. This clearly shows that studies of owls based on acoustic-lure techniques (Reid et al. 1999) are biased towards detection of owls that are paired and defending territories. This is not surprising given that there is ample evidence in the literature that non-territorial "floaters" are less detectable than are territorial birds (Rhoner 1997*a, b*). In spotted owls, the low detection of young owls occurs because many floaters either do not respond to acoustic-lure surveys, or respond in a very tenuous fashion such that they are difficult to capture or resight. Because of this bias, mark-recapture studies of spotted owls that rely on the acoustic-lure technique have fo-

cused on the territorial population (Burnham et al. 1994, 1996).

Because we observed no evidence of breeding by floaters, we agree with Rhoner (1997*b*) that floating behavior in owls is not an alternative reproductive strategy whereby non-territorial birds share mates with territorial birds. If, as Rhoner (1997*b*) suggested, spatial knowledge is paramount to hunting success and survival, then floaters would be expected to occupy temporary home ranges from which they could regularly sample or "prospect" (Eadie and Gauthier 1985) the underlying network of territorial pairs for opportunities to acquire a territory. In this context, floating is the result of territorial behavior, which excludes floaters from obtaining territories. The fact that many spotted owls do not obtain territories until they are 2–5 years old suggests that the number of floaters generally exceeds the number of available territories and that territorial behavior of established residents excludes floaters from the breeding population.

## Causes of Mortality

In our study, predation by great horned owls and other raptors was the primary source of mortality of young owls. Starvation, mammalian predation and accidents accounted for the rest. Although we suspected great horned owls were responsible for the majority of cases of avian predation, we could only positively confirm this in 3 cases where we found remains in great horned owl nests or pellets. It is possible that some of the kills that we suspected were caused by great horned owls could have been caused by barred owls (Leskiw and Gutiérrez 1998) or other spotted owls. Forsman et al. (1984) also reported predation on juvenile spotted owls by great-horned owls. Sources of mortality reported for great gray owls (*Strix nebulosa*) by Duncan (1987:105) were similar to our data for spotted owls in that predation by great-horned owls was the primary source of mortality (56.5%), followed by mammalian predation (21.7), starvation (8.7%), accidents (4.4%), and other/unknown (8.7%). We also observed goshawks (*Accipiter gentilis*) and red-tailed hawks (*Buteo jamaicensis*) attempting to capture spotted owls on a number of occasions, and suspected that they were responsible for some predation. The high incidence of parasitic infections that we observed in owls that were necropsied suggested that parasitism or disease may have predisposed some individuals to starvation or predation, as has been suggested by Hunter et al. (1987, 1997), Gutiérrez (1989), and Hoberg et al. (1989).

## Causes of Natal Dispersal

Hypotheses regarding the evolution of dispersal in organisms fall into 3 main groups, (1) intrasexual competition, (2) inbreeding avoidance or optimal inbreeding, and (3) spatio-temporal variation in resources. The logic underlying the intrasexual competition hypothesis is that animals disperse because they are physically excluded from settling on their natal sites and other occupied territories by individuals of the same sex, including their own parents (Moore and Ali 1984, Liberg and von Schantz 1985, Waser 1985). Once they began to disperse, there is little doubt that young spotted owls are excluded from acquiring territories by resident territory holders. However, we never observed any evidence that adults evicted their offspring from the territory, and we never observed any cases where juveniles settled on their natal territories and reproduced with 1 of their parents. Instead, it appeared that juveniles voluntarily dispersed after the adults stopped feeding and associating with them. Similarly, Beske (1982) saw no sign of parent/offspring aggression prior to dispersal of juvenile harriers (*Circus cyaneus*). Moore and Ali (1984) suggested that the absence of overt aggression between adults and offspring was not necessarily a contradiction of the intrasexual competition hypothesis, because juveniles might disperse simply because they were made to feel unwelcome or were aware of the threat imposed by the presence of a dominant individual. However, it does

seem that if intrasexual competition was the primary cause of dispersal, there would be at least some occasions when juveniles would remain on their natal sites when 1 or both of their parents died or dispersed. The fact that we never observed this suggests that something other than, or in addition to, intrasexual competition may be driving dispersal in the spotted owl. In contrast to the spotted owl, male burrowing owls (*Speotyto cunicularia*) in Saskatchewan frequently returned to breed at their natal sites (Wellicome et al. 1997).

An alternative to the intrasexual competition hypothesis is that dispersal evolved because it reduces the risk of close inbreeding (Lincoln 1934, Howard 1960, Greenwood and Harvey 1976). The fact that female birds typically disperse farther than males is sometimes cited in support of the inbreeding avoidance hypothesis (Greenwood 1980). However, Moore and Ali (1984) argued that differences in dispersal between males and females could be explained based solely on the basis of intrasexual competition for mates (territories) without invoking the inbreeding reduction hypothesis. The rarity of full-sib or parent-offspring inbreeding in spotted owls (this study, Carlson et al. 1998) and barn owls (Marti 1999) suggests that dispersal in these species does result in very low rates of close inbreeding. However, the comparatively short distances dispersed by spotted owls does result in frequent pairings between more distant relatives (cousins, aunts, uncles, grandparents, or great grandparents) (Reid and Forsman, unpublished data). Similar observations with other species of birds led Shields (1983) to suggest that the philopatric nature of dispersal in most organisms was designed not to avoid inbreeding, but to insure an "optimal" level of inbreeding in which individuals are more likely to breed with relatives than with unrelated individuals.

Although some have suggested that sex-biased dispersal is a means of avoiding close inbreeding, others have argued that greater male philopatry might be a product of a resource defense mating system in which males defend the primary resources, and females select among males (Greenwood 1980). In support of this hypothesis, Greenwood (1980) argued that males would have an advantage if they settled on or near their natal site, in that they would be more familiar with the resources in that area and would have reduced dispersal cost. Since females do not have to defend resources in this system, Greenwood argued that they could spend more time and energy searching for a suitable male, and would not be as severely penalized by unfamiliarity with the resource. Secondarily, he suggested that philopatry of males might occur if females tended to mate preferentially with males of a similar genotype. Aside from the fact that there is no evidence to suggest that female spotted owls mate preferentially with related males, the most troublesome aspect of the resource familiarity hypothesis relative to owls is that most juveniles move rapidly away from the natal area during the first few days or weeks of dispersal (Miller and Meslow 1985, Ganey et al. 1998, Belthoff and Ritchison 1989, Rhoner 1997*a, b*). In this situation, it is unlikely that dispersing males would initially be any more familiar with resources in territories near the natal site than areas farther away. A more plausible explanation, suggested by Small and Rusch (1989), is that males are less likely to travel as far as females simply because the intensive sampling process required to locate and defend a territory prohibits males from sampling large areas quickly, whereas females are free to travel widely, sampling many territories to find a suitable mate.

Another explanation for the ubiquitous nature of dispersal in organisms is that spatio-temporal or chaotic variation in fitness values of habitat patches may favor dispersal in patchy environments (Holt 1985, McPeek and Holt 1992, Holt and McPeek 1996). As a general explanation for dispersal this hypothesis seems reasonable for spotted owls, which evolved in forest landscapes that were regularly impacted by fire, windstorms, and other natural disturbances. However, it does not address

the causes of sex-biased dispersal. Also, if we assume that natal patches typically have high fitness values, it seems odd that juvenile spotted owls almost never settle at their natal site, even when there is a turnover event that removes 1 or both of their parents.

## Breeding Dispersal

Spotted owls seem to fit the general pattern for long-lived birds that occupy relatively stable environments in that they have high site fidelity from 1 year to the next, and site fidelity tends to increase with age (Richdale 1957, Darley et al. 1977, Newton and Marquiss 1982, Saurola 1987). In contrast, site fidelity of owls that occupy more variable habitats is less predictable. For example, annual site fidelity of breeding barn owls in Scotland was >95% (Taylor 1994:198), but was apparently much lower in Germany and Holland where >40% of banded adults dispersed from their initial banding locations (Bairlien 1985, as summarized by Taylor 1994: 199). Great gray owls and boreal owls may remain on the same territories from 1 year to the next in good prey years, but many individuals change territories in poor prey years, often moving long distances before breeding again (Duncan 1987, Hayward et al. 1993).

Our data suggest that spotted owls were more likely to undertake breeding dispersal if (1) they were female, (2) they were young, (3) they did not nest in the previous year, (4) they did not have a mate in the previous year, or (5) their mate from the previous year died or moved to a new territory. These results generally agree with other studies of birds that have shown that rates of breeding dispersal were higher for females, young birds, birds that lost a mate through death or divorce, or birds that failed at nesting (Coulson 1966, Newton and Marquiss 1982, Greenwood and Harvey 1982, Greig-Smith 1982, Bowen et al. 1989, Taylor 1994, Wellicome et al. 1997, Marti 1999, Daniels and Walters 2000). One hypothesis for higher rates of female breeding dispersal is that, in a territorial defense system in which the male locates and defends the territory, it may be more difficult for males to switch territories than it is for females to switch mates (Emlen and Oring 1977, Greenwood and Harvey 1982). A possible explanation for higher rates of breeding dispersal by young birds is that there may be strong competition for high-quality territories, which results in many young birds initially settling on lower-quality sites and then moving to higher-quality sites as they grow older (Greenwood and Harvey 1982).

Although many adult movements followed the death or disappearance of a mate, many also involved cases of divorce or territory switching by pairs. This suggests a strategy in which owls attempted to increase their fitness by switching to better territories or more fecund mates or both (Korpimäki 1988, Goodburn 1991, Newton and Willie 1992, Ens et al. 1996, Daniels and Walters 2000). Tests of these hypotheses were beyond the scope of this paper. In addition, we caution against the assumption that divorce always represents a voluntary choice on the part of the individual that moves, because floaters sometimes displace residents (Forsman 1975, Choudhury 1995).

## Spatially Explicit Simulation Models of Dispersal

Simulation models used to evaluate dispersal typically include numerous simplifying assumptions regarding search patterns of dispersers and rates of territory vacancy (e.g., Wasser 1985, Lande 1988, Doak 1989, Noon and Biles 1990, Tonkyn and Plissner 1991, Lamberson et al. 1992, Boyce et al. 1994, Dunning et al. 1995). Most researchers who have attempted to model spotted owl populations have assumed that juveniles perish fairly quickly if they do not acquire territories, and that the search for available territories occurs in 1 of 2 ways: (1) the animal searches territories that are intersected by a randomly assigned straight line radiating outward from the natal site, or (2) the animal searches all territories within a certain ra-

dius of the natal site (Wasser 1985, Lande 1988, Tonkyn and Plissner 1991, Lamberson et al. 1992). Contrary to these simplifying assumptions, our data suggest that at least some juveniles disperse and persist for ≥ 5 years as floaters in the population, and that dispersers use a series of temporary home ranges to systematically sample or "prospect" the underlying network of resident territories along a somewhat erratic dispersal path. Rhoner (1997*b*) described similar dispersal patterns in young great horned owls. These results suggest that more realistic spatial population models for spotted owls might be developed in which it is assumed that natal dispersers can search for potential territories for 5 or more years and that search patterns of individuals are highly variable, ranging from some individuals that sample only a few territories near the natal site to a small minority of individuals that sample large numbers of territories out to about 120 km from the natal territory. Obviously, the sexual differences in dispersal distances that we observed should also be assumed in any model.

## MANAGEMENT IMPLICATIONS

Distances moved by young spotted owls are such that genes can travel long distances in only a few generations. Thus, it is not surprising that recent genetic studies have found little evidence of meta-population structure in the northern spotted owl (Barrowclough et al. 1999, Haig et al. 2001). Our results also suggest that a conservation strategy that consists of numerous, closely spaced reserves of old forest (e.g., the Northwest Forest Plan) is not likely to result in genetic or demographic isolation of local populations, simply because dispersal between reserves will be a common occurrence, even if landscapes between the reserves consist of highly fragmented forests. Thus, we believe that concerns regarding genetic or demographic isolation of spotted owls that might result from a management plan like the Northwest Forest Plan are largely unfounded, except for areas isolated by large natural barriers (e.g., the Olympic Peninsula), or by extensive areas of intensively managed young forest (e.g., the coastal mountains of northwest Oregon and southwest Washington). Even if some areas are somewhat isolated, this may not be of particular concern from a genetic or demographic standpoint if populations within those areas are large, as is the case on the Olympic Peninsula (Holthausen et al. 1995).

In recent efforts to develop management plans for the northern spotted owl it has been assumed that forested regions between the large lowland valleys of western Oregon function as dispersal pathways for spotted owls between the Coastal Mountains and Cascades Mountains (Thomas et al. 1990, FEMAT 1993). Our data clearly demonstrate that this is the case, and that concerns regarding the importance of these areas as dispersal "corridors" for spotted owls are warranted.

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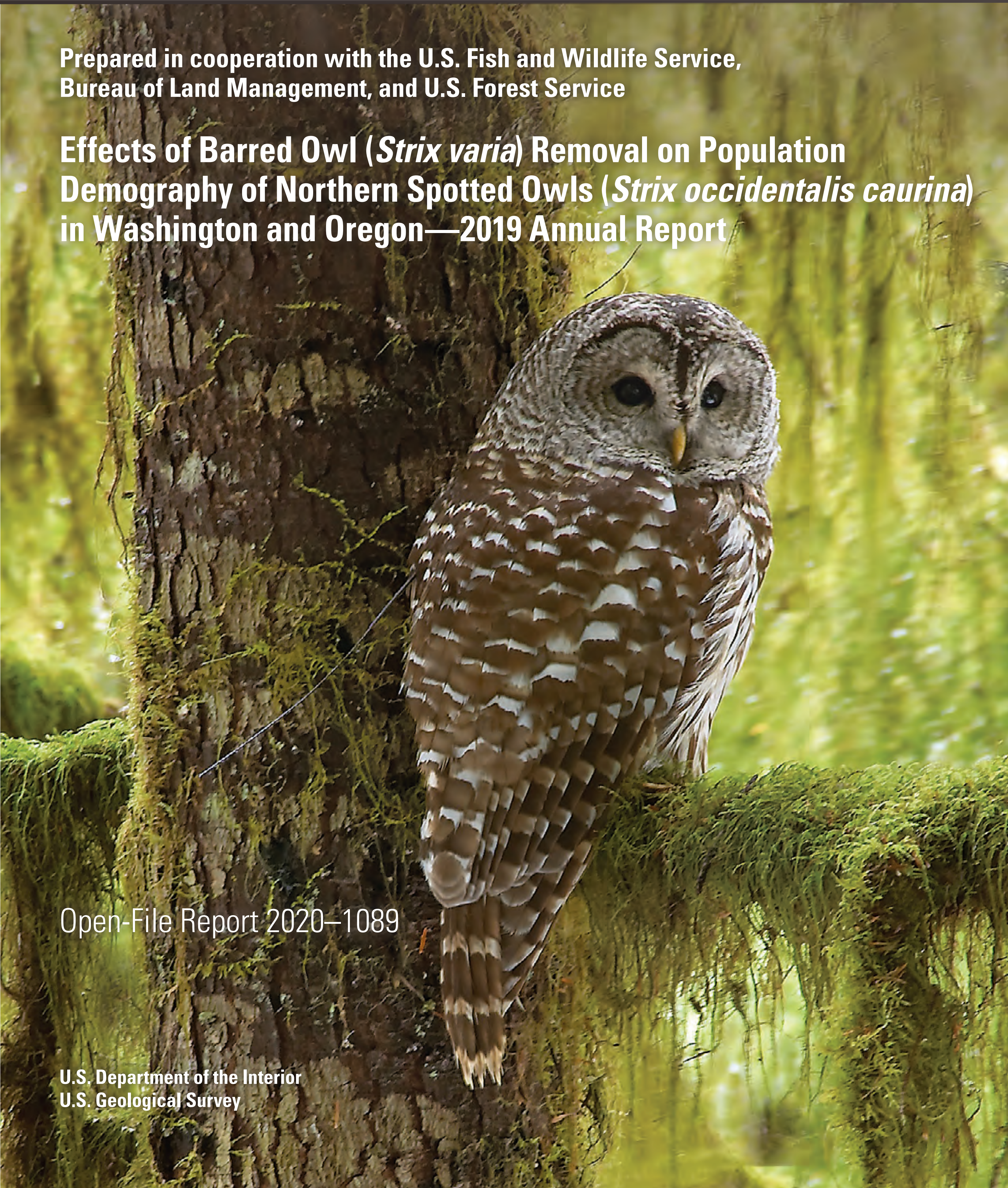
# EXHIBIT F

Prepared in cooperation with the U.S. Fish and Wildlife Service, Bureau of Land Management, and U.S. Forest Service

# Effects of Barred Owl (*Strix varia*) Removal on Population Demography of Northern Spotted Owls (*Strix occidentalis caurina*) in Washington and Oregon—2019 Annual Report



Open-File Report 2020–1089

U.S. Department of the Interior
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# Conversion Factors

International System of Units to U.S. customary units

| Multiply | By | To obtain |
|---|---|---|
| | Length | |
| meter (m) | 3.281 | foot (ft) |
| | Area | |
| square kilometer ($km^2$) | 0.3861 | square mile ($mi^2$) |

# Effects of Barred Owl (*Strix varia*) Removal on Population Demography of Northern Spotted Owls (*Strix occidentalis caurina*) in Washington and Oregon—2019 Annual Report

By J. David Wiens[1], Katie M. Dugger[2], Damon B. Lesmeister[3], Krista E. Dilione[1], and David C. Simon[1]

## Abstract

*Strix occidentalis caurina* (northern spotted owl; hereinafter referred to as spotted owl) have rapidly declined throughout the subspecies' geographic range. Competition with invading *Strix varia* (barred owl) has been identified as an immediate cause of those declines. A pilot study in California showed that removal of barred owls coupled with conservation of suitable habitat conditions can slow or even reverse population declines of spotted owls. It is unknown, however, whether similar results can be obtained in areas with different forest conditions, greater densities of barred owls, and fewer remaining spotted owls. We used a before-after-control-impact (BACI) experimental design on three study areas with long-term demographic information on spotted owls to determine if removal of barred owls can improve population trends of spotted owls. This report summarizes research accomplishments and initial results from the first 4.5 years (from March 2015 to August 2019) of implementing barred owl removal experiments in Washington and Oregon.

## Introduction

Over the past century *Strix varia* (barred owls) have expanded their geographic range west from eastern North America, and their newly expanded range now completely overlaps that of the federally threatened *S. occidentalis caurina* (northern spotted owl). Evidence indicates that competition with invading barred owls has contributed greatly to declines in spotted owl populations (Wiens and others, 2014; Dugger and others, 2016; Yackulic and others, 2019). A pilot study in coastal California demonstrated that removal of barred owls in combination with conservation of suitable forest conditions can slow or even reverse the rate of population decline in spotted owls (Diller and others, 2014, 2016). It remains unknown, however, whether similar results can be obtained in areas with different forest types, greater densities of barred owls, and fewer remaining spotted owls.

In 2015 we initiated a comprehensive before-after-control-impact (BACI) experiment to determine the demographic response of spotted owls to localized removals of barred owls (Wiens and others, 2019). The removal experiment was based on three long-term demographic study areas for spotted owls in Washington and Oregon. The goal of the experiment is to provide a definitive test of whether competitive interactions with barred owls cause population declines of spotted owls, and if so,

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whether removal of barred owls is an effective tool to consider in long-term management of the two owl species (Johnson and others, 2008; U.S. Fish and Wildlife Service, 2013). Specific objectives of the study are to:

1. Determine the effect of removal of barred owls on vital rates and population trend of spotted owls; and
2. Estimate changes in the occurrence and distribution of barred owls to assess the effectiveness of removals in reducing populations of barred owls.

The purpose of this report is to provide a summary of preliminary results from the first 4.5 years (from March 2015 to August 2019) of removal experiments implemented in Oregon and Washington. The results are considered preliminary, pending final analyses and completion of the study.

## Study Areas

The barred owl removal experiment was spatially replicated in four study areas, each with long-term (1990–2019) data on population demography of spotted owls. This report focuses on initial results from three of these study areas: Cle Elum (Washington), Coast Range (Oregon), and Klamath-Union/Myrtle (Klamath-UM, Oregon, table 1; fig. 1). Experimental study areas were selected based on many considerations, including availability of pre-treatment demographic data on spotted owls, land ownership, and the need to identify the effect of barred owls on spotted owls across a broad range of forest conditions co-occupied by the two owl species (see U.S. Fish and Wildlife Service, 2013 for details on selection of study areas). Each study area was divided into two or more similar areas where barred owls were either removed (treatment areas) or not removed (control areas). The study areas are composed of mostly Federal lands, but fieldwork also occurred on adjacent State, Tribal, and private lands with written permission from the landowner.

**Table 1.** Study areas, years of removal effort, and samples sizes used to estimate the effects of barred owl removal on population dynamics of northern spotted owls in Washington and Oregon.

[Number of spotted owl territories: Historically occupied territories surveyed for northern spotted owls annually during 2002–19. Number of spotted owls banded: Number of individually color-marked spotted owls used to estimate demographic rates. Number of barred owl sites: Hexagonal plots used to survey barred owls. km$^2$, square kilometer; --, no data]

| Treatment level | Removal start year | Total area (km$^2$) | Number of: | | |
|---|---|---|---|---|---|
| | | | Historical spotted owl territories | Spotted owls banded, 2002–2019 | Barred owl sites (5 km$^2$ hexagons) |
| Cle Elum, Washington | | | | | |
| Control | -- | 670 | 31 | 50 | 109 |
| Treatment | 2015 | 604 | 45 | 52 | 112 |
| Coast Range, Oregon | | | | | |
| Control | -- | 1,015 | 58 | 152 | 178 |
| Treatment | 2015 | 582 | 45 | 84 | 102 |
| Klamath-UM, Oregon | | | | | |
| Control | -- | 698 | 78 | 238 | 122 |
| Treatment | 2016 | 783 | 84 | 242 | 142 |

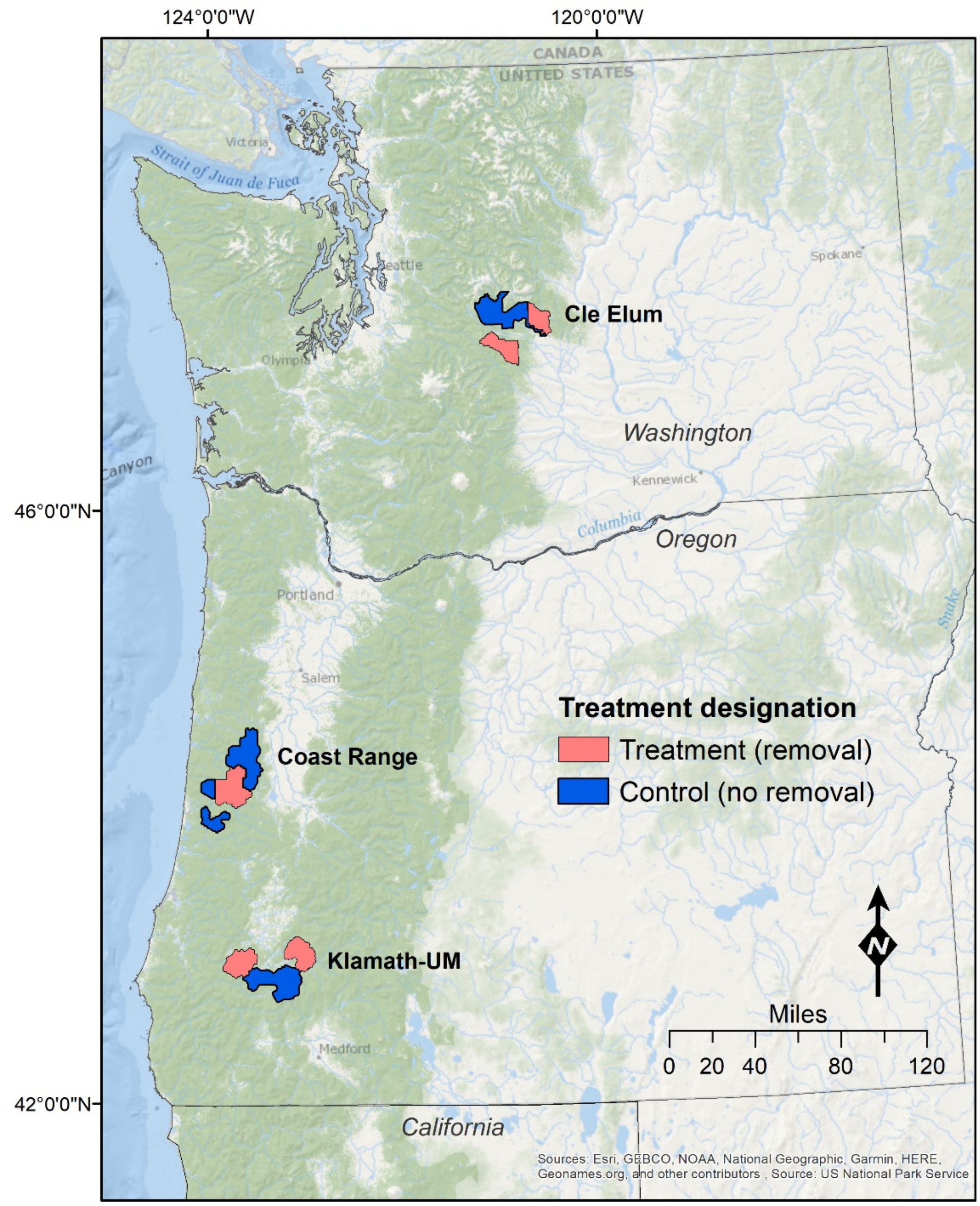


**Figure 1.** Locations of treatment (barred owls removed) and control (no removal) portions of three study areas in Washington and Oregon used to characterize the effect of barred owl removal on population dynamics of northern spotted owls.

# Methods

## Owl Surveys and Population Monitoring

We used species-specific surveys to document BACI changes in populations of spotted owls and barred owls. Annual surveys and mark-recapture studies of spotted owls at historically occupied territories were completed as part of a long-term demographic monitoring program (Franklin and others, 1996, Lint and others, 1999; Dugger and others, 2016). Recent summaries of spotted owl population trends, breeding and mate status of detected owls, number of owls banded, inter-territory movements and general age distribution are reported elsewhere (Lesmeister and others, 2020a–c).

We used a standard site-occupancy design described by Wiens and others (2011) to survey barred owls. Mean home-range size for barred owls in the Pacific Northwest ranges from 4–7 square kilometers ($km^2$) (Wiens and others, 2014). Using home-range size as a guide, a grid of 5-$km^2$ hexagons was overlaid across each study area. We considered each hexagon grid cell a site and surveyed each site repeatedly over three sampling periods within the breeding season: March 1–May 7, May 8 – July 9, and July 10 – September 10, 2019. Sampling periods reflected approximate transition dates between incubation, nestling, and fledgling-dependency breeding stages of barred owls (Wiens and others, 2011; 2014). During each survey, observers used an amplified megaphone (FoxPro, Lewiston, Pennsylvania; Wildlife Technologies, Manchester, New Hampshire) to broadcast digitally recorded calls of barred owls at two to five call points established in each site. Observers recorded the number and sex of barred owls detected during each survey. A site was considered used by at least one territorial pair of barred owls if (1) both sexes were observed within 400 meters (m) of each other on a single visit or (2) at least one adult was observed with young (Wiens and others, 2011).

## Barred Owl Removal

We used well-established field protocols for the removal and scientific collection of barred owls (Diller and others, 2014, 2016; U.S. Fish and Wildlife Service, 2013). Barred owls detected in treatment areas were removed using 12-gauge shotguns loaded with nontoxic shot. We observed frequent recolonization by barred owls, so we did regular followup visits to detect newly colonizing barred owls and conduct additional removals as needed. We determined sex of barred owls in the field based on vocalizations and morphometric measurements, and later verified those determinations in the lab by examining sex organs. We classified barred owls as either subadults (owls in their 1st or 2nd year) or adults (owl 3 years and older) based on molt and plumage characteristics observed under ultraviolet light (Weidensaul and others, 2011), and by identifying juvenile flight feathers. Barred owls were stored locally at each study area until distributed as scientific specimens to museums and universities (app. 1).

The protocol for removals we used prohibited collection of barred owls with dependent young (U.S. Fish and Wildlife Service, 2013). As a consequence, we completed removals in the nonbreeding season (September–April) or in cases where observers had high confidence in determining reproductive status of individuals (U.S. Fish and Wildlife Service, 2013). Such cases were typically at sites where we documented rapid (within 2–3 weeks) recolonization of new barred owls after removing of the previous occupants in early spring, prior to the estimated mean hatching date for barred owls (~April 15; Wiens and others, 2014). Breeding season removals were generally focused in areas known to be recently occupied by spotted owls. We were unable to complete breeding season removals in the Cle Elum study area during 2016–18 because snow limited access to removal sites in early spring. All barred owl removals were conducted by personnel certified by the U.S. Geological Survey. Field protocols used for

surveys and lethal removals of barred owls were reviewed and approved by the Institutional Animal Care and Use Committee at Oregon State University and were completed under Federal and State Scientific Collection permits.

## Assessing the Initial Effects of Removals

### Barred Owl Occupancy Dynamics

We used multi-season occupancy models (MacKenzie and others, 2002, 2006) to track annual changes in barred owls on control versus treatment areas and quantify the effectiveness of removals in reducing populations. We focused inferences from the analysis on detections/non-detections of at least one pair of barred owls because territorial pairs have the potential to reproduce and may defend their territories more aggressively than single birds,. Site-specific detection histories were used to estimate the probability (1) of use by at least one pair of barred owls in the year prior to removals (initial occupancy, $\psi_1$); (2) that used sites become unused (local extinction, $\varepsilon$); (3) that unused sites become used (local colonization, $\gamma$); and (4) of detecting at least one pair of barred owls given the site was used (p). Actual territory boundaries (defended areas) may overlap more than one hexagon used for surveys, so we interpreted occupancy as the probability of a used territory (defended area) overlapping with a 5-$km^2$ survey site (that is, site usage; Kendall and others, 2013; Davis and others, 2018). We retain the term occupancy to maintain standardized terminology used for this modeling approach. At survey sites with year-round removal of non-nesting barred owls ($n$ = 39), we considered only surveys within a breeding season that occurred prior to removal of the last barred owl to minimize bias of parameter estimates (Diller and others, 2016).

We used program MARK (White and Burnham, 1999) to determine how removals and time (year) influenced the occupancy dynamics of barred owls. We first examined the effects of treatment level (control versus treatment), year, and visits within years on detection probability. After retaining the best structure for detection, we moved on to model initial occupancy, colonization, and then extinction. We examined evidence for treatment effects on extinction and colonization rates as a group effect, which allowed parameter estimates to vary between sites with and without removals. We compared support for models with and without the effect of barred owl removal included and used information theoretic methods to rank and select among competitive models (Burnham and Anderson, 2002). We calculated model-averaged estimates where appropriate, and evaluated the degree to which 95-percent confidence intervals of regression coefficients ($\beta$) overlapped zero to supplement evidence of treatment effects.

### Spotted Owl Territory Occupancy and Reproduction

We used long-term (2002 – 2019) monitoring data on spotted owls to summarize estimates of numbers of territorial pairs detected, naïve occupancy (proportion of historical territories surveyed with detections of resident pairs of spotted owls), and reproduction (mean number of young produced per pair and total number of young produced per year). Because detection probabilities of spotted owls are below 1 (Dugger and others, 2016), empirical data presented in this report may underestimate actual numbers or territory occupancy of spotted owls. Analyses that account for imperfect detection in estimates of the effects of barred owl removal on population dynamics of spotted owls are forthcoming.

# Results

## Barred Owl Surveys and Removals

From 2015 to 2019, we completed 8,004 surveys of barred owls at 765 hexagons (409 control and 356 treatment). By August of 2019, the mean number of individual barred owls detected per hexagon in treatment (removal) areas had decreased by 77 (Cle Elum study area), 44 (Coast Range study area) and 47 (Klamath-UM study area) percent relative to pretreatment estimates (fig. 2). In control areas, the mean number of barred owls detected increased by 14 (Coast Range study area) to 69 (Klamath-UM study area) percent in Oregon, but declined by 19 percent in Washington. We detected 2–3 times as many barred owls in the Coast Range relative to the other 2 study areas (fig. 2).

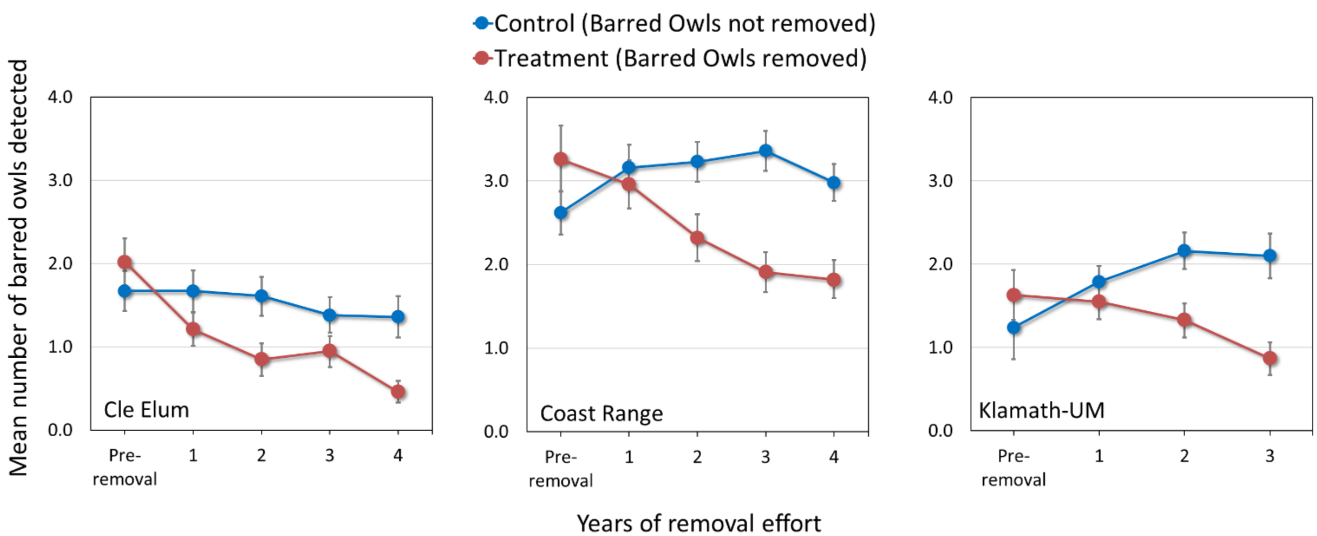


**Figure 2.** Average number of barred owls detected per 5-km$^2$ hexagon in control (barred owls not removed) and treatment (barred owls removed) portions of three study areas before and after barred owls were removed in Washington and Oregon, 2015–19. Annual means were calculated as the maximum number of individuals detected per hexagon, divided by the total number of hexagons surveyed. Error bars represent standard error.

Field crews completed 4,384 site visits to remove a total of 2,066 barred owls: 486 in the Cle Elum study area, 1,034 in the Coast Range study area, and 546 in the Klamath-UM study area (fig. 3). The sample included 908 females, 1,107 males, and 51 owls of unknown sex. A minimum of 412 territorial pairs of barred owls were removed. We recovered 2,048 carcasses – 18 carcasses could not be recovered because they were either too high in a tree to reach, fell onto areas unsafe for access, or could not be located after a single lethal shot. Forty-two (2.1 percent) barred owls required euthanasia using an Institutional Animal Care and Use Committee -approved penetrating bolt device (Bunny Rancher Inc., Frankfort, Maine). There were no known cases where a nontarget species was injured or mistakenly killed. Carcasses of barred owls were provided as scientific specimens to 28 different institutions for education and research purposes (app. 1).

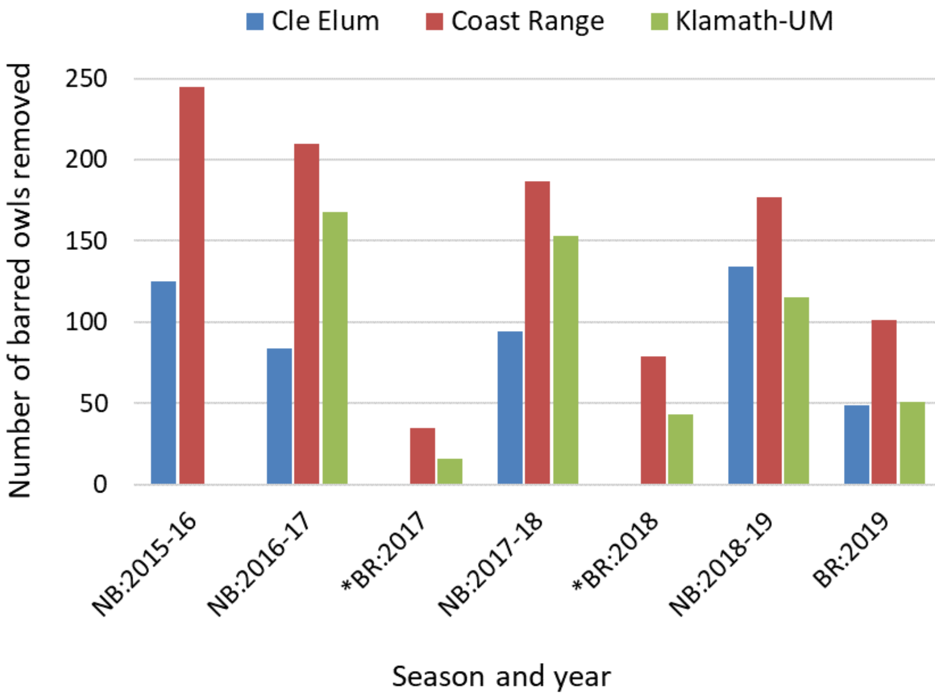


**Figure 3.** Numbers of barred owls removed by season in three experimental study areas in Washington and Oregon, 2015–19. Nonbreeding (NB) and breeding (BR) seasons were from September 1 to April 15 and April 16 to August 31, respectively. Removals during the breeding season (*) were not conducted in 2016 and were limited to the Coast Range and Klamath-UM study areas in 2017 and 2018.

We observed a high level of spatial variation within and among study areas in numbers of barred owls removed, which we attributed to regional- and site-specific differences in the rate of recolonization following removals (fig. 4, also see Barred Owl Occupancy Dynamics below). The mean number of barred owls removed per 5-$km^2$ hexagon during the study period was 4.6 in the Cle Elum study area (range = 0–26 owls), 10.0 in the Oregon Coast Range study area (range = 0–46 owls), and 3.8 in the Klamath-UM study area (range = 0–22 owls).

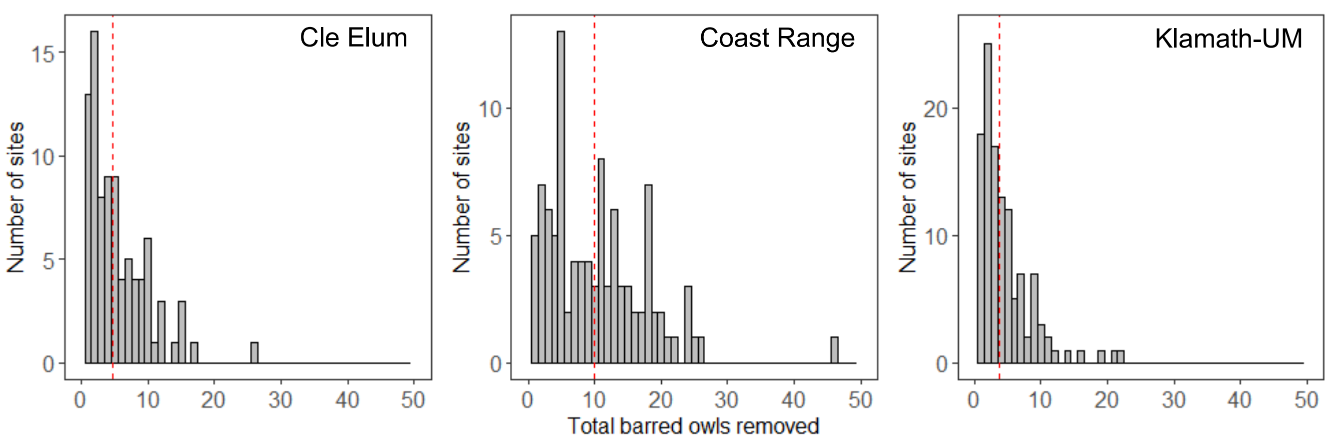


**Figure 4.** Variation among study areas and sites (5 $km^2$ hexagons) in numbers of barred owls removed during 2015–19. The mean number of barred owls removed per site over 3 (Klamath-UM study area) to 4 (Cle Elum and Coast Range study areas) years of removal effort is indicated by a dashed vertical red line.

## Initial Effects of Removals

### Barred Owl Occupancy Dynamics

Before removals, there was no evidence of differences between control and treatment areas in expected site occupancy of barred owls (fig. 5; app. 2). After removals, expected occupancy of barred owls in treatment areas declined by 13 (Coast Range study area) to 60 (Cle Elum study area) percent relative to pretreatment estimates (table 2). In contrast, expected occupancy in control areas remained relatively constant (Coast Range and Klamath-UM study areas) or was slowly decreasing (Cle Elum study area). The effectiveness of removals in reducing site occupancy, as shown by differences between control and treatment areas in post-removal years, varied substantially among the three study areas (table 2, fig. 5).

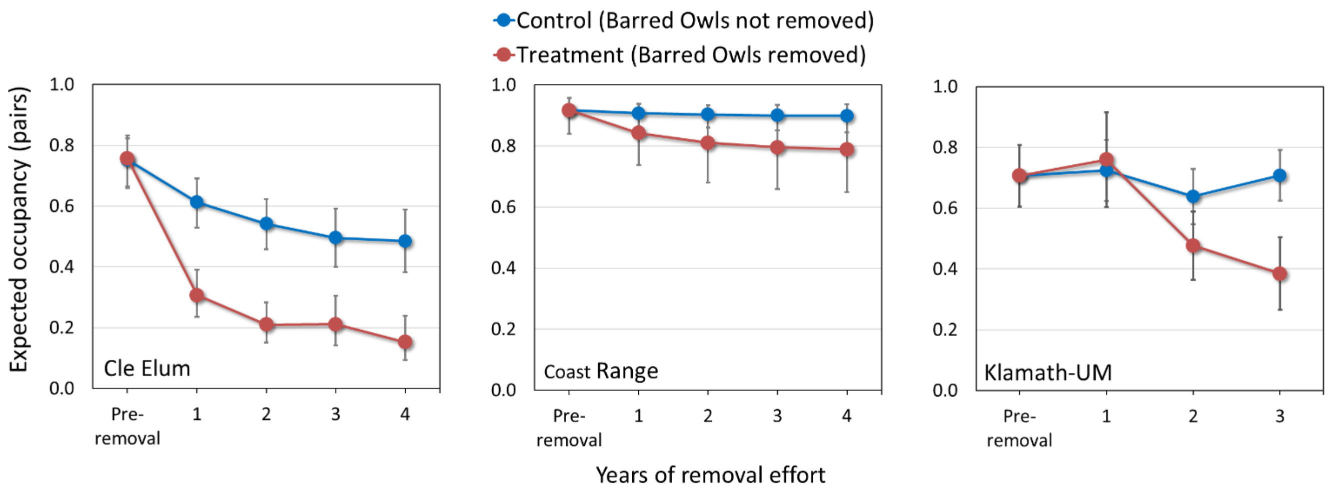


**Figure 5.** Model-averaged estimates of landscape occupancy ($\widehat{\overline{\psi}}$) by territorial pairs of barred owls in control (barred owls not removed) compared to treatment (barred owls removed) portions of three study areas in Washington and Oregon, 2015–19. Error bars are unconditional 95-percent confidence intervals.

There was strong evidence that removals increased local extinction probabilities of barred owls in all three study areas (apps. 2, 3). Models that included the effect of treatment on extinction probability consistently outperformed models without this effect, and 95-percent confidence intervals of associated beta coefficients did not include zero (app. 2). By 2019, extinction rates were 2.7–4.6 times greater in treatment sites relative to controls (app. 3). We found weak evidence of treatment (removal) effects on local colonization of barred owls. Post-removal recolonization rates of barred owls in treated areas were substantially greater in the Coast Range study area ($\hat{\gamma}$ = 0.42, SE = 0.12) than in the Cle Elum ($\hat{\gamma}$ = 0.09, SE = 0.05) or Klamath-UM study areas ($\hat{\gamma}$ = 0.17, SE = 0.07; app. 3). The consistently high annual rate of recolonization by new territorial pairs we observed in the Coast Range study area largely compensated for the negative effect of removals on expected site occupancy (table 2; fig. 5).

**Table 2.** Model-averaged estimates of expected occupancy ($\hat{\psi}$) by territorial pairs of barred owls, with unconditional standard errors (SE) and lower (LCL) and upper (UCL) confidence limits, before and after removals in three experimental study areas in Washington and Oregon, 2015–19.

[%Δ = percent change in expected occupancy during the study period ($\hat{\psi}_{pre} - \hat{\psi}_{2019} \times 100$). $\hat{\lambda}_{2019}$ = model averaged annual rate of change in occupancy between 2018 and 2019]

| Treatment level | Model-averaged estimates | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\hat{\psi}_{pre}$ | SE | LCL | UCL | $\hat{\psi}_{2019}$ | SE | LCL | UCL | %Δ | $\hat{\lambda}_{2019}$ |
| Cle Elum, Washington | | | | | | | | | | |
| Control | 0.752 | 0.040 | 0.665 | 0.823 | 0.485 | 0.054 | 0.382 | 0.589 | −27 | 1.05 |
| Treatment | 0.757 | 0.044 | 0.660 | 0.833 | 0.153 | 0.037 | 0.094 | 0.239 | −60 | 0.52 |
| Coast Range, Oregon | | | | | | | | | | |
| Control | 0.917 | 0.029 | 0.840 | 0.959 | 0.899 | 0.023 | 0.844 | 0.936 | −2 | 1.00 |
| Treatment | 0.917 | 0.029 | 0.840 | 0.959 | 0.789 | 0.060 | 0.649 | 0.883 | −13 | 0.99 |
| Klamath-UM, Oregon | | | | | | | | | | |
| Control | 0.707 | 0.052 | 0.606 | 0.808 | 0.708 | 0.042 | 0.625 | 0.791 | <1 | 1.11 |
| Treatment | 0.707 | 0.052 | 0.606 | 0.808 | 0.385 | 0.061 | 0.265 | 0.504 | −32 | 0.81 |

## Spotted Owl Territory Occupancy and Reproduction

Long-term data prior to barred owl removals show sharp declines in annual numbers of resident spotted owls detected in control and treatment areas (fig. 6*A*). In the year prior to removals (2016 in the Klamath-UM study area, 2015 in the other areas), the total number of pairs of spotted owls detected across all control and treatment areas combined was 30 and 17, respectively (table 3)[4]. After 3–4 years of removal effort, the total number of pairs detected was 5 and 19, respectively. This total represented an 83-percent decrease in numbers of pairs on control areas compared to a 12-percent increase in numbers on treated areas with barred owl removal. Post-removal changes were most pronounced in the Oregon Coast Range study area, where the number of pairs detected in treated areas has doubled during the study yet decreased by 91 percent in control areas (table 3; fig. 6*A*).

Long-term empirical data show that the annual number of fledgling spotted owls produced in control compared to treatment areas was highly variable among years and study areas (fig. 6*B*). In 2019, ten (91 percent) of 11 pairs of spotted owls that successfully fledged young were in treatment areas with barred owl removal (table 4). Differences in spotted owl reproduction in control compared to treatment areas were most pronounced in the Klamath-UM study area. All pairs that successfully produced young in 2019 in the Klamath-UM study area were in areas with consistent, year-round barred owl removal effort.

[4]Data on spotted owls are specific to control and treatment portions of each study area, so may vary from estimates reported in these areas by Regional Ecosystem Office (www.fs.fed.us/r6/reo/monitoring/reports/).

**Table 3.** Annual estimates of territory occupancy by pairs of northern spotted owls in control (barred owls not removed) and treatment (barred owls removed) portions of three study areas in Washington and Oregon, 2015–18.

[Shading indicates years in which barred owls were removed in treatment areas (four years in Cle Elum and Oregon Coast Range, three years in Klamath-UM]

| Treatment level | Historical territories surveyed | Number of territories with pairs of spotted owls detected (proportion of historical territories with pairs in parentheses) | | | | |
|---|---|---|---|---|---|---|
| | | 2015 | 2016 | 2017 | 2018 | 2019 |
| | | Cle Elum, Washington | | | | |
| Control | 32 | 5 (0.16) | 2 (0.06) | 2 (0.06) | 3 (0.09) | 1 (0.03) |
| Treatment | 45 | 2 (0.04) | 2 (0.04) | 2 (0.04) | 3 (0.07) | 3 (0.07) |
| | | Coast Range, Oregon | | | | |
| Control | 58 | 11 (0.19) | 9 (0.16) | 6 (0.10) | 1 (0.02) | 1 (0.02) |
| Treatment | 45 | 3 (0.07) | 5 (0.11) | 4 (0.09) | 6 (0.13) | 6 (0.13) |
| | | Klamath-UM, Oregon | | | | |
| Control | 78 | 18 (0.23) | 14 (0.18) | 12 (0.15) | 5 (0.06) | 3 (0.04) |
| Treatment | 84 | 22 (0.26) | 12 (0.14) | 13 (0.15) | 12 (0.14) | 11 (0.13) |

**Table 4.** Annual estimates of reproduction of northern spotted owls in control (barred owls not removed) versus treatment (barred owls removed) portions of three study areas in Washington and Oregon, 2015–18.

[Shading indicates years in which barred owls were removed in treatment areas (four years in Cle Elum and Oregon Coast Range, three years in Klamath-UM]

| Treatment level | Number of territories with ≥ one young fledged (proportion of sites with fledged young in parentheses) | | | | |
|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 |
| | Cle Elum, Washington | | | | |
| Control | 2 (0.06) | 0 | 2 (0.06) | 0 | 1 (0.03) |
| Treatment | 1 (0.02) | 2 (0.04) | 1 (0.02) | 0 | 3 (0.07) |
| | Coast Range, Oregon | | | | |
| Control | 3 (0.05) | 0 | 1 (0.02) | 0 | 0 |
| Treatment | 0 | 1 (0.02) | 2 (0.04) | 0 | 1 (0.02) |
| | Klamath-UM, Oregon | | | | |
| Control | 8 (0.10) | 1 (0.01) | 4 (0.05) | 1 (0.01) | 0 |
| Treatment | 6 (0.07) | 1 (0.01) | 2 (0.02) | 1 (0.01) | 6 (0.07) |

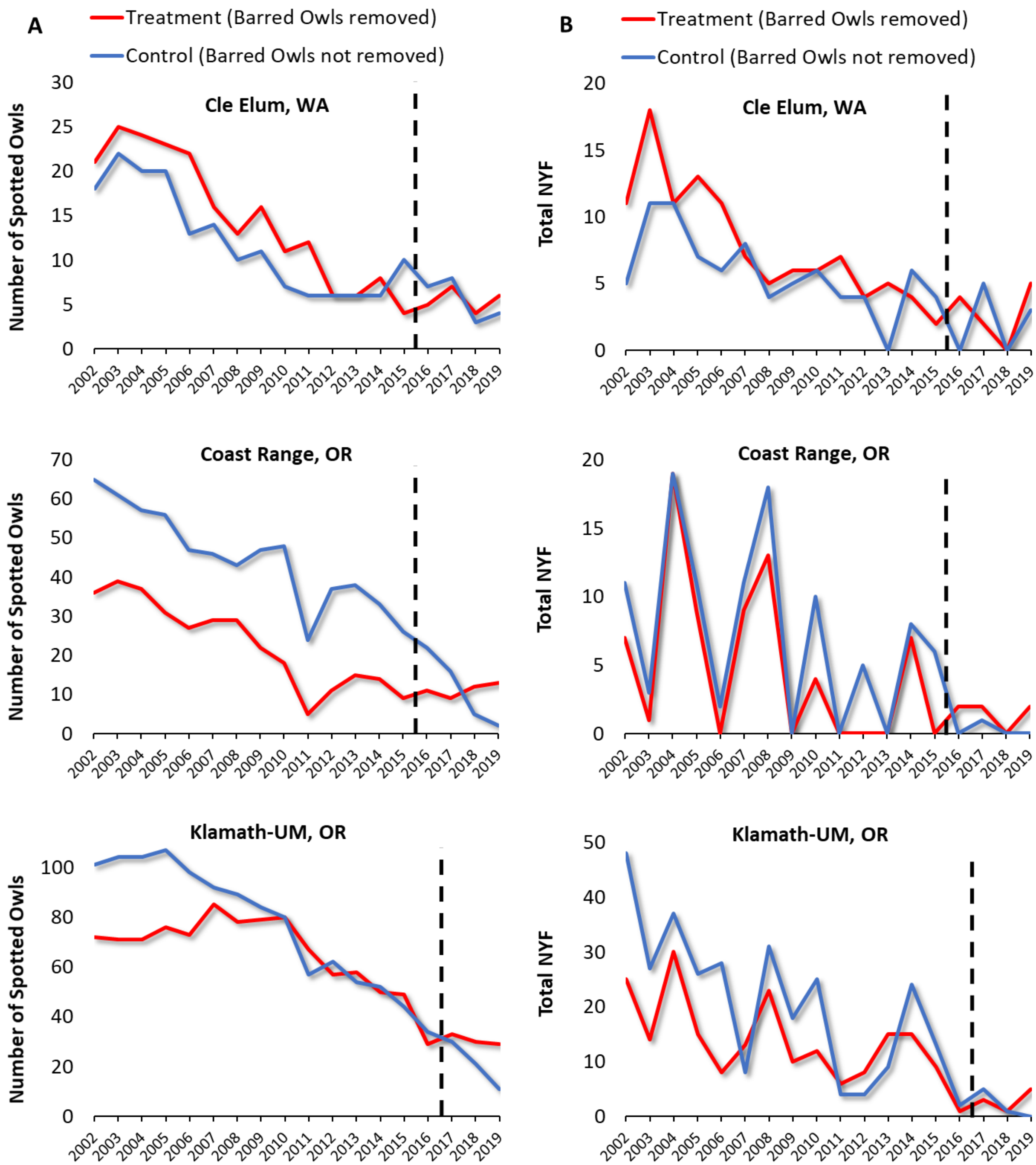


**Figure 6.** Long-term (2002–19) annual trends in (A) number of individual (resident) northern spotted owls detected, and (B) total number of young fledged (NYF) at control (barred owls not removed) and treatment (barred owls removed) portions of three experimental study areas in Washington and Oregon. Dashed vertical bars indicate the start date of removals in treatment areas.

## Discussion

Long-term data prior to removals illustrate sharp declines in annual numbers of resident spotted owls detected in control and treatment portions of all three study areas in Oregon and Washington. The declining trend of spotted owls continued in control areas during the study, where an overall 83 percent decline was observed over 4 years in the numbers of territorial pairs detected. In contrast, there was a 12-percent increase in numbers of pairs in treated sites during barred owl removal. These data are preliminary and conclusions from the experiment are pending final and forthcoming analyses of the demographic response of spotted owl to barred owl removal. Moreover, data presented here do not account for imperfect detection of spotted owls during demographic surveys, so may underestimate actual numbers of pairs or individuals, or reproductive output. Nonetheless, the initial results indicate that the numbers of resident spotted owls have been maintained in treated landscapes yet have continued along a declining trajectory in control areas. Posttreatment changes in numbers of spotted owls detected appeared to be the greatest in the Oregon Coast Range study area, where the number of territorial pairs in treated areas has doubled during the study but numbers in control areas have declined by 91 percent. This initial result was surprising because barred owls in the Oregon Coast Range study area also had the highest recolonization rates following removals, which partially compensated for the effect of removals on landscape occupancy of barred owls.

In 2019, ten of 11 pairs (91 percent) of spotted owls that successfully produced young in our study areas were in areas with barred owl removal. This pattern was largely driven by a discrepancy in reproductive effort of spotted owls in control compared to treatment areas of the Klamath-UM study area (table 3B). In previous studies, a high degree of annual variation in productivity of spotted owls, before and after removal efforts, obscured the ability to quantify how removals affect fecundity of spotted owls (Diller and others, 2016). Low and highly variable reproduction in our study areas in years prior to and during removals (fig. 6*B*) suggests this may be the case in our study areas as well. Planned analyses of spotted owl reproduction will examine BACI effects of barred owl removal on the mean number of young fledged per territory monitored (for example, table 3B), in addition to fecundity, to better understand how barred owl removal may affect productivity of spotted owls.

Our initial assessment of occupancy dynamics of barred owls indicated that removals effectively reduced populations in treated areas by 13 (Oregon Coast Range study area) to 60 (Cle Elum study area) percent with 3–4 years of removal effort. We also found no evidence that site-occupancy by barred owls varied between control and treatment areas in the year prior to removals. This finding provided confidence that control and treatment areas had similar use by barred owls prior to treatments, and that post-treatment changes could be reliably attributed to removals. In the Oregon study areas, barred owl occupancy remained constant or increased slightly in control areas over time, as would be expected if populations were continuing to expand (or nearing carrying capacity). In contrast, there was a slight reduction observed in barred owl occupancy in the control area of the Cle Elum study area, suggesting that other factors may be influencing populations in these study areas. A consistently high level of spatial variation among sample sites in numbers of barred owls removed (fig. 4, for example) was also observed, which may reflect spatial heterogeneity in habitat quality for colonizing barred owls. Planned analyses will incorporate site-level habitat and disturbance characteristics to more fully characterize how these factors interact with removals to affect colonization or extinction dynamics of barred owls.

## Summary

During 2015–19, we completed annual demographic surveys of *Strix varia* (barred owl) and *Strix occidentalis caurina* (spotted owl) at 765 and 341 5-square kilometer sites, respectively, and a total of 2,066 barred owls were removed from treatment areas. Preliminary results indicate that removals have greatly increased the site-level extinction probability of barred owls and decreased the probability of site use by barred owls across all experimental study areas. In 2019, we detected consistent or increasing numbers of resident spotted owls in treatment areas relative to previous years, with correspondingly sharp decreases in control areas without removals. Collectively, these initial results provide an indicator that removal efforts may be positively influencing territory occupancy, apparent survival, and population trend of spotted owls in the study areas. The numbers of spotted owls remaining in our study areas have reached exceptionally low levels, and annual reproduction during our study period was the lowest recorded over a 28-year period. Moreover, long-term pre-treatment monitoring data show large inter-annual fluctuations in detections of pairs and individual spotted owls in all the study areas. Final conclusions drawn from the experiment are pending final and forthcoming analyses of the demographic response of spotted owls to barred owl removal.

## Acknowledgments

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# Appendix 1. Disposition of Barred Owl Specimens

**Table 1.1.** Disposition of barred owl specimens collected during removal experiments in Washington and Oregon, 2015–19.

| Destination | Purpose | Number of owls |
|---|---|---|
| Field Museum (Chicago, Illinois) | Museum specimen | 425 |
| University of California, Riverside (Riverside, California) | Museum specimen or research | 79 |
| Oregon State University (Corvallis, Oregon) | Museum specimen or research | 78 |
| Cornell University Museum of Vertebrates (Ithaca, New York) | Museum specimen | 72 |
| University of Arizona (Tucson, Arizona) | Museum specimen or research | 68 |
| University of California, Berkeley (Berkeley, California) | Museum specimen | 67 |
| Western Foundation of Vertebrate Zoology (Camarillo, California) | Museum specimen | 59 |
| Bell Museum at University of Minnesota (St Paul, Minnesota) | Museum specimen | 50 |
| Burke Museum (Seattle, Washington) | Museum specimen | 30 |
| Cleveland Museum of Natural History (Cleveland, Ohio) | Museum specimen | 30 |
| Montezuma Audubon Center (Savannah, New York) | Museum specimen | 30 |
| Academy of Natural Sciences of Drexel University (Philadelphia, Pennsylvania) | Museum specimen | 25 |
| California Academy of Sciences (San Francisco, California) | Museum specimen or taxidermy | 24 |
| Moore Laboratory of Zoology at Occidental College (Los Angeles, California) | Museum specimen | 20 |
| Finger Lakes Community College (Canandaigua, New York) | Classroom education or research | 19 |
| Florida Museum of Natural History (Gainesville, Florida) | Museum specimen | 19 |
| Natural History Museum of Los Angeles County (Los Angeles, California) | Museum specimen | 19 |
| University of Colorado Museum of Natural History (Boulder, Colorado) | Museum specimen | 19 |
| The Smithsonian Institution (Washington D.C.) | Museum specimen | 17 |
| University of Wyoming Museum of Vertebrates (Laramie, Wyoming) | Museum specimen | 15 |
| Peabody Museum of Natural History at Yale University (New Haven, Connecticut) | Museum specimen | 12 |
| State University of New York College at Cortland [SUNY Cortland] (Cortland, New York) | Classroom education | 11 |
| Liberty Wildlife Non-Eagle Feather Repository (Phoenix, Arizona) | Native American repository | 10 |
| Museum of Comparative Zoology at Harvard University (Cambridge, Massachusetts) | Museum specimen | 9 |
| Kansas University Biodiversity Institute & Natural History Museum (Lawrence, Kansas) | Museum specimen | 9 |
| U.S. Geological Survey Forest and Rangeland Ecosystem Science Center Snake River Field Station (Boise, Idaho) | Scientific research | 3 |
| Oregon Department of Forestry (Tillamook, Oregon) | Taxidermy display | 1 |
| High Desert Museum (Bend, Oregon) | Live capture; educational bird | 1 |
| **Total barred owls provided** | | **1,221** |

# Appendix 2. Multi-Season Occupancy Models Used to Characterize Occupancy Dynamics of Barred Owls

**Table 2.1.** Ranking and structure of multi-season occupancy models used to characterize the effects of removals on barred owls in three study areas in Washington and Oregon, 2015–19.

[Model parameter structure and the estimated direction of treatment (removal) effects are shown for all competitive models ($\Delta$AICc $\leq$ 2.5) for each individual study area. Bold denotes beta coefficients with 95-percent confidence intervals that did not overlap zero. $\widehat{\Psi}_{pre}$, probability of occupancy in the year before removals began (initial occupancy); $\hat{\varepsilon}$, the probability that a previously used site was not used in the subsequent year (extinction); $\hat{\gamma}$, the probability that a previously unused site was used in the subsequent year (colonization); $\hat{p}$, the probability of detection; trt, treatment; Time effects were modeled as constant (.) or varying with survey period (survey), year, or a before-after indicator of when removals began on treatment areas (trtBA). AICc = Akaike's Information Criterion for small sample size, $\Delta$AICc = difference between the AICc value of each model and the lowest AICc model, K = the number of model parameters, and deviance was the difference in −2[log(Likelihood)] of the current model and −2[log(Likelihood)] of the fully saturated model.]

| Occupancy model | Model parameter | | | | Model selection criteria | | | |
|---|---|---|---|---|---|---|---|---|
| | $\widehat{\Psi}_{pre}$ | $\hat{\varepsilon}$ | $\hat{\gamma}$ | $\hat{p}$ | $\Delta$AICc | wi | K | Deviance |
| Cle Elum, Washington | | | | | | | | |
| 1 | . | trt (+) | trt (−) × yr | survey, trt (−) | 0.00 | 0.30 | 15 | 165.5 |
| 2 | . | trt (+) | . | survey, trt (−) | 0.47 | 0.24 | 8 | 180.3 |
| 3 | . | trt (+) | yr | survey, trt (−) | 0.96 | 0.18 | 11 | 174.7 |
| 4 | . | trt (+) | trt (−) | survey, trt (−) | 2.21 | 0.10 | 9 | 180.0 |
| Coast Range, Oregon | | | | | | | | |
| 1 | . | trt (+) | . | yr, survey, trtBA (−) | 0.00 | 0.63 | 24 | 1040.0 |
| 2 | . | trt (+) | trt (+) | yr, survey, trtBA (−) | 1.41 | 0.31 | 25 | 1039.3 |
| Klamath-UM, Oregon | | | | | | | | |
| 1 | . | trt (+), yr | . | yr × survey | 0.00 | 0.40 | 19 | −82.1 |
| 2 | . | trt (+), yr | yr | yr × survey | 0.50 | 0.31 | 21 | −85.8 |
| 3 | . | trt (+), yr | trt (−) | yr × survey | 2.04 | 0.14 | 20 | −82.2 |

# Appendix 3. Post-Removal Extinction and Colonization Rates of Barred Owls

**Table 3.1.** Estimated local extinction and colonization rates of barred owls following removal on treatment portions of three study areas in Oregon and Washington, 2018–19.

| Study area and treatment level | Estimate 2018–19 | Standard error | Lower (LCL) and upper (UCL) 95-percent confidence limits | |
|---|---|---|---|---|
| | | | LCL | UCL |
| Local extinction ($\hat{\varepsilon}$) | | | | |
| Cle Elum, Washington | | | | |
| Control | 0.192 | 0.048 | 0.115 | 0.303 |
| Treatment | 0.613 | 0.057 | 0.498 | 0.717 |
| Coast Range, Oregon | | | | |
| Control | 0.044 | 0.013 | 0.025 | 0.077 |
| Treatment | 0.118 | 0.049 | 0.050 | 0.253 |
| Klamath-UM, Oregon | | | | |
| Control | 0.002 | 0.017 | 0.000 | 0.036 |
| Treatment | 0.398 | 0.109 | 0.213 | 0.618 |
| Local colonization ($\hat{\gamma}$) | | | | |
| Cle Elum, Washington | | | | |
| Control | 0.166 | 0.069 | 0.070 | 0.347 |
| Treatment | 0.089 | 0.047 | 0.031 | 0.233 |
| Coast Range, Oregon | | | | |
| Control | 0.382 | 0.084 | 0.235 | 0.554 |
| Treatment | 0.424 | 0.118 | 0.222 | 0.655 |
| Klamath-UM, Oregon | | | | |
| Control | 0.175 | 0.070 | 0.076 | 0.353 |
| Treatment | 0.173 | 0.069 | 0.075 | 0.351 |

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Wiens and others--**Effects of Barred Owl Removal on Population Demography of Northern Spotted Owls**—2019 Annual Report—OFR 2020-1089

ISSN 2331-1258 (online)
https://doi.org/10.3133/ofr20201089

# EXHIBIT G

United States
Department of
Agriculture

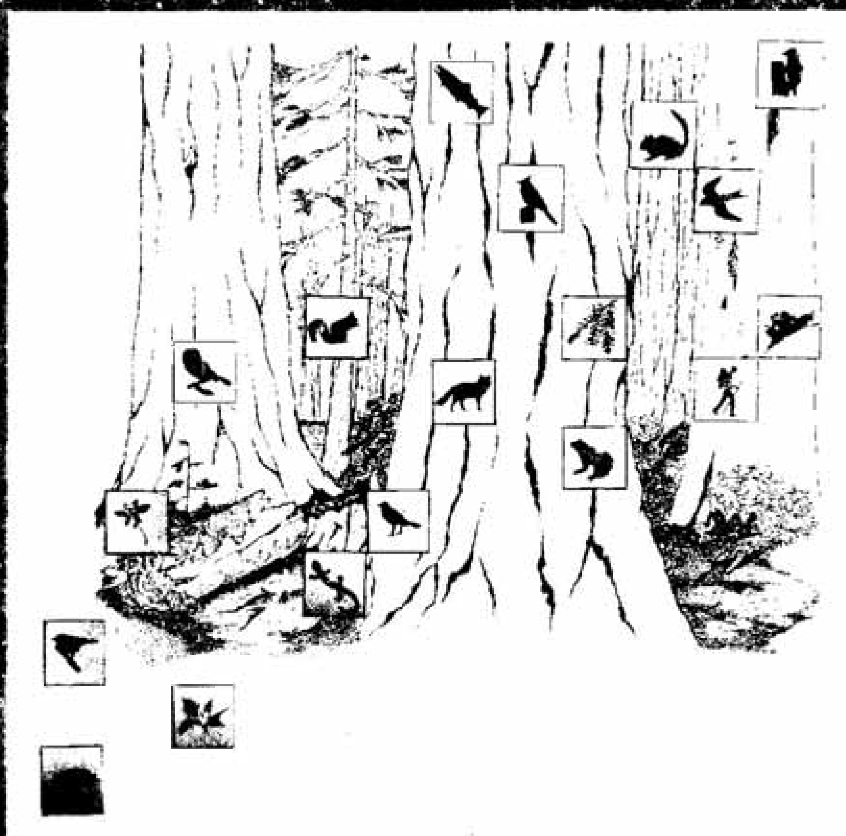
National
Forest
System

Forest
Service
Research

March 1993

# Viability Assessments and Management Considerations for Species Associated with Late-Successional and Old-Growth Forests of the Pacific Northwest

The Report of the Scientific Analysis Team



**Northern Spotted Owl and the Northern Spotted Owl Recovery Planning process is also discussed." (A)**

Miller, G.S.; DeStefano, S. 1992a. Field and analysis methods for spotted owl demographic studies. Proceedings of the 62nd annual meeting of the Cooper Ornithological Society symposium; 1992 June 22-28; Seattle, WA.

**"Spotted Owls were located on each study area using calling surveys (vocal imitations and playback) conducted both during the day and at night. Spotted owls were captured using a noose or snare pole and banded with USFWS lock-on bands and a colored plastic leg band. Reproductive status was determined by mousing the birds. Sites where spotted owls had been banded in previous years were resurveyed each year to confirm bands and band new birds. Capture history arrays of l's and O's were developed for all banded birds, where a 1 indicated that a marked bird was seen >1 times during the year and a 0 indicated that the individual was not observed for that year. Survival estimates and resighting probabilities were calculated using capture-recapture methodology. We used programs RELEASE and SURGE for data summarization, model selection and fit, and parameter estimation." (A)**

Miller, G.S.; DeStefano, S.; Brown, M.T., [and others]. 1992b. Demography of spotted owls in the central Cascades, Oregon. Proceedings of the 62nd annual meeting of the Cooper Ornithological Society symposium; 1992 June 22-28; Seattle, WA.

**"Demographics of the northern spotted owl were studied in the central Cascades of western Oregon between 1987 and 1991. A total of 358 individual owls were banded over the S-year period with yearly surveys conducted to re-sight marked birds. Re-sighting rates were high, especially for the adult age class. Mean fecundity for adult females was 0.30. Survival was higher for adults than juveniles and for adult males vs. adult females. The rate of change in territorial adult females/year was calculated, with lambda significantly less than 1. Population dynamics and the significance of the lambda calculation are discussed." (A)**

Montgomery, C.A.; Brown, G.M.; Adams, D.M. 1992. The marginal cost of species preservation: the northern spotted owl. Missoula, MT: University of Montana, School of Forestry; draft. 35 p.

**"Because species survival is not certain, the decision to "save " a species is not an all-or-nothing choice but rather a marginal one. The appropriate unit for both benefit and cost functions is like the likelihood of survival and the appropriate question is how certain we want to be of species survival. The intensity of the species preservation debate is also fired by strong equity concerns. We illustrate these points for the case of the northern spotted owl by constructing a marginal cost curve for its survival and by disaggregating welfare loss by region and by market level." (A)**

Reid, J.A.; Forsman, E.D.; Lint, J.B. 1992. Demography of spotted owls in west central Oregon. Proceedings of the 62nd annual meeting of the Cooper Ornithological Society symposium; 1992 June 22-28; Seattle, WA.

**"A capture-recapture study of northern spotted owls (*Strix occidentalis caurina*) began on the Roseburg District of the Bureau of Land Management in west-central Oregon in 1985. The study area is commercial forest land of alternating sections of Federal**

**and private ownership. The sample of marked owls included 469 adult/subadults (207 females, 262 males) and 239 juveniles. Sex and age specific models indicated similar survival rates of males and females. The preferred model produced a survival estimate of 0.857 (s.e.= 0.0211 for females and 0.846 (s.e. = 0.017) for males. Juvenile survival varied depending on the model used. The preferred model produced a juvenile survival estimate of 0.405 (s.e. = 0.136). There was no time effect on survival or recapture probabilities for either females or juveniles. The preferred model indicated a time dependence on survival rates for males. An average fecundity rate was 0.330 (s.e.= 0.039) for adult females and 0.094 (s.e. = 0.055) for subadult females. Mean lifespan for adults/subadults was 6.5 years contingent upon the individual reaching one year of age."**

**"Estimated population growth rate (lambda) was 0.0964 (s.e.= 0.037). This indicates a declining population of resident owls. However, the estimate of lambda is not significantly different from 1 (p = 0.168). Future years of study will provide more precise estimates." (A)**

Rinkevich, S.E. 1992. Distribution and habitat characteristics of Mexican spotted owls in Zion National Park, Utah. Raptor Research Foundation 1992 annual meeting: Proceedings of a spotted owl symposium; 1992 November 11-15; Bellevue, WA.

**"Distribution, habitat characteristics, and food habits of the Mexican spotted owl (*Strix occidentalis lucida*) were investigated in Zion National Park. Two hundred and twenty-nine surveys were conducted in canyon and plateau habitat between May-August 1989 and April-August 1990. I located owls in nine different locations; each owl was associated with narrow canyons, "hanging" canyons, and cliff sites. The minimum estimated density in Zion National Park was 0.02 owls/kin$^2$ in 1989 and 0.03/kin$^2$ in 1990. Spotted owls were widely distributed and coincident with discontinuous habitat within the park."**

**"I used stepwise discriminate analysis to examine the habitat differences between (1) observed owl microsites and available microsites and (2) observed owl canyon habitat and available canyon habitat. Spotted owl microsites had higher humidity, more vegetation strata, narrower canyon widths, and higher percentage of ground litter than available microsites. Habitat within owl use canyons had higher humidity and higher total snag basal area than available canyon habitats. Owls may be selecting canyon habitat not only for the structural habitat features but also for the microclimate. The presence of canyons and cliffs may provide necessary refuge from high daytime temperatures that occurred in the study area. Mexican spotted owls do not appear to depend on extensive stands of old-growth forests as do northern spotted owls (*S. occidentalis caurina*) because this type of habitat is lacking in Zion Park. Seventy-one prey items were identified from 60 pellets collected from two owl territories. Mammals comprised 99.9 percent of estimated biomass and 80.3 percent of the total diet composition. Bushy-tailed woodrats (Neotoma cinerea) were the primary prey taken by owls. They comprised 67.3 percent of the estimated biomass and 40.3 percent by frequency of the diet. Further studies are needed to investigate the habitat requirements of spotted owls in the northern region of its range." (A)**

Rowland, M.J. 1992. Northern spotted owl litigation review. Raptor Research Foundation 1992 annual meeting: Proceedings of a spotted owl symposium; 1992 November 11-15; Bellevue, WA.

# EXHIBIT H

# United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Oregon State Office
P.O. Box 2965
Portland, Oregon 97208
http://blm.gov/or

**JUL 21 2017**

**IN REPLY REFER TO:**
1610 (OR932) I

EMS TRANSMISSION 07/21/2017
Information Bulletin No. OR-2017-063

To: District Managers for Coos Bay, Lakeview, Medford, Northwest Oregon, and Roseburg Districts

From: Deputy State Director for Division of Resources, Lands, Minerals, and Fire Oregon/Washington

Subject: Timber Sale Planning Approaches to Avoid Take of Northern Spotted Owls Under the 2016 Resource Management Plans

The purpose of this information bulletin (IB) is to suggest approaches to the National Environmental Policy Act and Endangered Species Act compliance for timber sale planning and to facilitate consistency with resource management plan (RMP) management direction and guidance related to northern spotted owls.

**Background**

The 2016 Resource Management Plans for Western Oregon provide the following management direction for timber harvest and northern spotted owl conservation:

> "Do not authorize timber sales that would cause the incidental take of northern spotted owl territorial pairs or resident singles from timber harvest until implementation of a barred owl management program consistent with the assumptions contained in the Biological Opinion on the RMP has begun."

In order for the BLM to successfully achieve the desired outcomes envisioned under the 2016 RMPs, timber sale planning will need to consider and accommodate the dynamic nature of the owl occupancy information. Without careful planning, this requirement could potentially disrupt timber sale scheduling. The Bureau of Land Management (BLM) Oregon State Office (OSO), with assistance from the U.S. Fish and Wildlife Service, suggests consideration of a situational management approach to timber sales, analyzed in a programmatic National Environmental Policy Act document. Situational management is a simple, focused adaptive management

approach with clearly, defined triggers and management options. More detailed discussion is provided in the attached paper which was developed by an interagency team comprised of BLM OSO, district, and field office staff and the U.S. Fish and Wildlife staff.

**Contact:** Please direct any questions concerning this IB to OSO Planning and Environmental Coordinator Richard Hardt at (541) 683-6690, OSO Wildlife Biologist Bruce Hollen at (503) 808-6604, or OSO O&C Forester Abe Wheeler at (503) 808-6451.

**Districts with unions** are reminded to notify their unions of this IB and satisfy any bargaining obligations before implementation. Your servicing Human Resources Office or Labor Relations Specialist can provide you with assistance in this matter.

Signed by
Cathy L. Harris
Associate Deputy State Director for
Resources, Lands, Minerals and Fire

Authenticated by
K. Wentworth
Records Section

Attachment
1 – Timber Sale Planning Approaches to Avoid Take of the Northern Spotted Owls Under the 2016 Resource Management Plans (28pp.)

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# Timber Sale Planning Approaches to Avoid Take of Northern Spotted Owls under the 2016 Resource Management Plans

## Contents

## Executive Summary

The 2016 Resource Management Plans (RMPs) for Western Oregon provide the following management direction for timber harvest and northern spotted owl (owl) conservation:

> "Do not authorize timber sales that would cause the incidental take of northern spotted owl territorial pairs or resident singles from timber harvest until implementation of a barred owl management program consistent with the assumptions contained in the Biological Opinion on the RMP has begun." (Northwestern and Coastal Oregon ROD/RMP, p. 100; Southwestern Oregon ROD/RMP, p. 121).

Without careful planning, this requirement could potentially disrupt timber sale scheduling. The Bureau of Land Management (BLM) Oregon State Office, with assistance from the U.S. Fish and Wildlife Service, suggests consideration of a situational management approach to timber sales, analyzed in a programmatic National Environmental Policy Act (NEPA) document to provide flexibility in timber sale planning and facilitate consistency with RMP management direction and guidance.

In order for the BLM to successfully achieve the desired outcomes envisioned under the 2016 RMPs, timber sale planning will need to consider and accommodate the dynamic nature of owl occupancy information. One tactic that the BLM could implement to more consistently achieve target levels of treated acres and timber harvest volume would be to keep more acres in the timber sale pipeline until owl occupancy information is brought up to date while minimizing up-front investment in project planning through a shift to a situational management approach within a programmatic NEPA analysis. This strategy could help the BLM avoid providing protections intended to prevent take in owl sites that are eventually shown to be unoccupied and afford a larger pool of candidate treatment areas from which to implement timber sales.

Situational management is a simple, focused adaptive management approach with clearly, defined triggers and management options. Situational management may be considered a series of "if … then" options. Situational management approaches may be useful in analyzing proposed timber harvests prior to completion of owl surveys (i.e., what actions the BLM would implement if owls are not found, and what actions the BLM would implement if owls are found). Situational management approaches can be analyzed within single-project, batched, or programmatic NEPA analysis.

Programmatic NEPA analyses are environmental assessments or environmental impact statements that provide a broad or high-level NEPA analysis for a category or group of actions. Programmatic NEPA analyses can reduce or eliminate redundant analyses and effectively address cumulative effects. Programmatic NEPA analyses can provide long-term efficiencies, but may require more up-front work than project-by-project analyses. Using programmatic analyses for timber sales would allow the BLM to move quickly from completing owl surveys, conducting fieldwork for timber sales, and issuing timber sale decisions. Shortening the time between completion of owl surveys and the timber sale decision would minimize the risk of lost work in the event of surveys finding owl occupancy.

The Endangered Species Act (ESA) consultation for timber sales would evaluate the proposed scope and intensity of the activities that could be authorized under a decision based on a single-project, batched, or programmatic NEPA analysis, evaluate consistency with the RMP Biological Opinion (BO), and reach concurrence on the project design criteria that could be implemented to avoid take. Consultation for a plan of work for routine timber sales, such as those authorized under a decision based on batched or programmatic NEPA analysis, would also establish processes for project-specific monitoring or reporting by the BLM to the U.S. Fish and Wildlife Service as needed.

This paper was developed by an interagency working group including:

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## Introduction

The 2016 Resource Management Plans (RMPs) for Western Oregon provide the following new management direction for timber harvest and northern spotted owl (owl) conservation:

> "Do not authorize timber sales that would cause the incidental take of northern spotted owl territorial pairs or resident singles from timber harvest until implementation of a barred owl management program consistent with the assumptions contained in the Biological Opinion on the RMP has begun." (Northwestern and Coastal Oregon ROD/RMP, p. 100; Southwestern Oregon ROD/RMP, p. 121).

Without careful planning, this requirement could potentially disrupt timber sale scheduling. The BLM Oregon State Office, with technical assistance from the U.S. Fish and Wildlife Service, has developed this paper to facilitate a more strategic approach to the timber sale planning and analysis processes that could create more efficient NEPA and ESA compliance and to better inform risk management decisions. Specifically, this paper suggests consideration of a situational management approach to timber sales analyzed in a programmatic NEPA document to provide flexibility in timber sale planning and facilitate consistency with RMP management direction and guidance.

## Timber Sale Planning Considerations

The BLM timber sale planning involves strategic, tactical, and operational level planning. Strategic plans are designed with the entire organization in mind and serve as the framework for lower level planning. The 2016 RMPs provide the strategic plans for BLM's Western Oregon forest management program. Tactical plans support strategic plans by translating them into specific plans relevant to a distinct localized area of the organization. Tactical planning for BLM forest management projects involves the evaluation, prioritization, and selection of eligible timber sale opportunities in the local landscape. Tactical planning should result in a five to ten year sale plan for each sustained yield unit. Operational plans focus on specific procedures to prepare and implement annual sale plans in each sustained yield unit. For the BLM, preparation and implementation of annual sale plans in each sustained yield unit fill the operational planning role.

Figure: Timber Sale Planning Phases

| Strategic | Tactical | | | Operational | | | |
|---|---|---|---|---|---|---|---|
| Pre-Planning | | Planning | | Preparation | | Administration | Monitoring |
| Eligible Unit Pool | Information gathering, resource surveys, property lines, inventory, access, scoping. | NEPA Unit Pool | ID Team field evaluation, harvest planning, NEPA analysis, public input. | Final Unit Pool | NEPA decision/ timber sale contract preparation | Protest, appeals, and litigation, active timber sale contract, contract termination | RMP and project level monitoring |
| 1-2 years | | 1-2 years | | 3-6 months | | 1-4 years (up to 36 months plus any delays) | Ongoing |

There are a number of specific tasks grouped into the timber sale planning phases of pre-planning, planning, preparation, administration, and monitoring. The above figure roughly illustrates the process and approximate timelines leading to implementation of timber sales. This orderly sequence of pre-planning through monitoring is often referred to as the timber sale pipeline.

In the pre-planning phase, eligible units are evaluated for treatment based on the management direction of the underlying RMP designated land use allocations and consideration of both current condition and desired future condition for both the landscape and individual forest stands. In this phase of project planning, eligible sale units would be evaluated against relevant local data including but not limited to owl location and occupancy history information. This process effectively results in the tactical plan, otherwise known as the long-range timber sale plan.

This tactical planning process will yield different results depending on the local context; some sustained yield units may have ample timber harvest opportunities with very low risk of negative impacts to owls. Other units may have more limited opportunities for timber harvest that would have low risk of negative impacts to owls. Ultimately, the BLM decision maker would balance these risks with the need to accomplish timber harvest targets while achieving other resource management objectives and direction set forth in the RMPs. It will always be necessary to over-plan harvest acres and volume to allow for inevitable reduction in acres and volume due to site-specific concerns.

Preliminary treatment areas must be selected three to five years in advance of the targeted timber sale auction date to allow for data collection, NEPA analysis, and sale preparation. Information about eligible units selected for treatment at this phase is generally limited to information in the BLM's corporate data coupled with local on-the-ground knowledge. Acres will often drop out of consideration for treatment due to economic viability, operational feasibility, silvicultural reasons, and owl occupancy, as well as other resource concerns. These complicating factors could lead to a situation in which too few candidate treatment acres remain in the timber sale pipeline to achieve timber harvest targets and other applicable RMP management direction.

In order for the BLM to successfully achieve the desired outcomes envisioned under the 2016 RMPs, timber sale planning will need to consider and accommodate the dynamic nature of owl occupancy. There is a risk that the BLM would invest a substantial amount of time and resources into planning a project that would eventually be dropped for consideration or substantially modified due to confirmed owl occupancy and avoidance of incidental take. For example, an owl activity center with continuous documented occupancy and reproduction for the last five years in high quality habitat might be considered to have a high probability of future occupancy (high risk). While an owl activity center that has not had detections within last five years and is surrounded by marginal habitat or recent clear-cuts may be considered to have a low probability of future occupancy (low risk). Evaluation of risk associated with owl sites where no surveys have been conducted for ten or more years would likely be based on habitat context (quality and quantity) and topography.

In the recent past, the BLM has typically pared the eligible unit pool down based in part on owl occupancy history (including assumed occupancy), and then pared the NEPA unit pool down again based on results of an up-to-date survey effort (actual occupancy). This has led to a reduction in eligible treatment acres in some sustained yield units resulting in the inability to achieve desired treatment outcomes and timber harvest targets. An area eligible for treatment that is dropped early in the process due to assumed occupancy cannot be readily brought back into the timber sale pipeline without major delays.

One tactic that the BLM could implement to more consistently achieve target levels of treated acres and timber harvest volume would be to keep more acres in the timber sale pipeline until owl occupancy information is brought up to date, while minimizing up-front investment in project planning through a shift to a situational management approach within a programmatic NEPA analysis. This strategy could keep the BLM from taking measures designed to avoid incidental take in owl sites that are eventually shown to be unoccupied, and afford a larger pool of candidate treatment areas from which to implement timber sales.

## Situational Management as a Specific Adaptive Management Approach

Adaptive management is a decision process that promotes flexible decision-making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Situational management is a simple-focused, adaptive management approach with clearly defined triggers and management options. Situational management may be considered a series of "if … then" options. Where there is a lack of information to support good assumptions about expected environmental conditions and likely treatments, situational management approaches may not be appropriate.

Situational management approaches can be analyzed within single project, batched, or programmatic NEPA analysis.

## Situational Management Approaches for Timber Sales

Situational management approaches may be useful in analyzing proposed timber harvests in a NEPA document prior to completion of owl surveys or the use of other best available information informing occupancy. In such situational management approaches, the BLM would provide descriptions of the specific actions the BLM would take at the project implementation stage once site-specific information is available. Such approaches would typically describe how and when site-specific information would be developed, such as completion of surveys (or other best available information). The NEPA analyses often include a situational management approach for species-specific management including surveys for project implementation. See Appendix 1 for examples of species-specific situational management approaches. The appropriate situational management approach will depend on a variety of factors, including risk tolerance, current information about owl occupancy, project features, and landscape conditions.

The following bullets are hypothetical examples of situational management approaches for timber harvests with respect to information about owl occupancy (see section below "Evaluating Take from Timber Harvest"):

- In an analysis of proposed regeneration harvest in a batch of several specific units in the Moderate Intensity Timber Area or Low Intensity Timber Area:
    - The proposed action may describe that units in which owl surveys find occupancy would be dropped to avoid incidental take.
    - The proposed action may describe that units in which owl surveys find occupancy would be harvested with a commercial thinning prescription designed to avoid incidental take.
- In an analysis of proposed integrated vegetation management in a batch of several specific units in the Uneven-aged Timber Area, the proposed action may describe different harvest prescriptions for units based on owl occupancy (e.g., "treat and maintain" prescriptions within occupied owl home ranges).
- In a programmatic analysis of commercial thinning and regeneration harvest in the Moderate Intensity Timber Area, Low Intensity Timber Area, or integrated vegetation management in Uneven-aged Timber Area, the proposed action may describe specific harvest types and prescriptions that would be applied under specific conditions (including stand characteristics and results of owl surveys) and set annual or cumulative maximum acres of harvest.

## Evaluating Take from Timber Harvest

In all of the above examples, any actual conclusion regarding take of owls would depend on site-specific conditions including information on owl occupancy, stand-specific habitat conditions, landscape habitat conditions, and timing of actions. An analysis of whether a particular harvest prescription applied under a specific set of habitat conditions within an occupied home range would or would not result in take would typically best be developed with technical assistance from the U.S. Fish and Wildlife Service early in the project development.

Determining the likelihood of take from habitat alteration is typically based on an approach in which the best available information on the species biology and needs is used to infer effects of a specific habitat alteration action to an identifiable individual of the listed population. There is a strong body of literature supporting conditions generally associated with owl occupancy and reproduction that can be used to assess the likelihood that an action would interfere with continued use of the site for survival and reproduction. While the literature is generally consistent, consultation provides an opportunity to refine the analysis specific to the ecological conditions of the action area. Appendix 2 provides a summarization of the literature and is consistent with the scientific information that has been used by the U.S. Fish and Wildlife Service in other owl consultations.

## NEPA Approaches and Best Practices

Field offices in western Oregon have routinely conducted NEPA analysis for single projects, batches of projects, and programs of work. The most efficient and effective structure for NEPA analysis depends in part on the level of certainty about environmental conditions and land management actions.

Field offices have prepared analyses for batches of timber sales and restoration actions in specific locations. These analyses are not actually programmatic in that they identify specific actions in specific locations. They represent a compilation of project-specific analyses, which may facilitate cumulative effects analysis. The ESA consultation for the individual actions under these batched decisions has typically been conducted as part of the regular batched consultations.

Figure: Structure for NEPA Analysis by Level of Certainty

| | | | |
|---|---|---|---|
| Level of Certainty (environmental conditions/ treatments) | ⬆ | | ⬇ |
| Structure for NEPA Analysis | Programmatic | Batched | Single Project |

In the above figure, the less certainty about environmental conditions (and corresponding treatments), the greater the need for up-front site-specific information and the less appropriate the project is for batched or programmatic analysis. This is due to the inability to make solid assumptions regarding specific conditions on the ground and how the treatments would occur based on those conditions.

Programmatic NEPA analyses are environmental assessments or environmental impact statements that provide a broad or high-level NEPA analysis for a category or group of actions. Programmatic NEPA analyses can reduce or eliminate redundant analyses and effectively address cumulative effects. Programmatic NEPA analyses can provide long-term efficiencies, but may require more up-front work than project-by-project analyses. Programmatic decisions typically require some loss of flexibility in individual project design (such as through descriptions of standard or required project design features). However, projects that do not conform to the programmatic decision can still be carried forward with project-specific NEPA analysis.

Programmatic NEPA analyses may not be effective when the design and effects of actions depends heavily on site-specific conditions that are unknown and cannot be anticipated. In considering whether programmatic NEPA analysis would be effective, field offices should consider whether the analysis can provide sufficiently specific information on treatments, environmental conditions, and effects to avoid the need for additional NEPA analysis at the individual project level.

Programmatic NEPA analyses can be structured around an entire program of work. In such analyses, the proposed action analysis may be truly programmatic in nature; that is, the proposed action describes the type of actions, typical design features, and the amount and extent of activities without identifying specific locations and timing of actions. The ESA consultation has typically, but not always, included issuance of a biological opinion on these programmatic decisions.

Programmatic NEPA analyses can also be structured around a suite of proposed actions in a specific geography. In such analyses, the proposed action may either describe specific actions, in specific locations, with specific timing, or describe types of actions and the conditions under which they would be implemented. These analyses describe the types of actions, and the typical conditions under which they would be implemented, and analyzed the effects based on typical project design features and typical levels of activity. The ESA consultation has typically, but not always, included issuance of a biological opinion on these programmatic decisions.

When implementing actions that rely on batched or programmatic NEPA analysis, field offices have typically completed a Determination of NEPA Adequacy (DNA) to support each project decision. The DNA should review and verify that the predicted conditions and treatments are as predicted (i.e., validating the assumptions in the batched or programmatic NEPA analysis) and address any new information (see the New Information section below). When completing a DNA to support an individual project decision that relies on a batched or programmatic NEPA analysis, evaluate whether the public involvement associated with the NEPA analysis is adequate for the individual project. For timber sales that rely on a batched or programmatic NEPA analysis, some type of public involvement prior to a decision on the timber sale will typically be appropriate, such as public notification or review of a completed DNA Worksheet (BLM NEPA Handbook H-1790-1, pp. 23-24).

See Appendix 3 for approaches to conducting programmatic analysis and examples of programmatic analyses for programs of work, programmatic analyses for suites of actions, and analyses of batched actions.

## Programmatic NEPA Analysis for Timber Sales

Field offices would need to identify the appropriate geographic scale of a timber sale programmatic analysis and the scope of activities. A programmatic analysis could facilitate producing a long-term timber sale plan, as described in the Forest Product Sale Procedure Handbook H-5410-1 Annual Forest Product Sale Plan (p. 3). This programmatic NEPA analysis could evaluate the full set of candidate treatment acres and potential harvest volume estimates, overlaying owl activity centers, as described in Appendix A of the RMPs, and considering other applicable management directions. The scale at which we would make this evaluation could vary, but a larger-scale evaluation (e.g., the field office or the sustained yield unit) would better facilitate tactical planning and take advantage of available corporate data. Field offices should determine which activities within the timber sale program to address within the programmatic analysis. It may be challenging to set appropriate sideboards for some specific timber harvests or specific situations without site-specific and project-specific information. Developing appropriate sideboards would typically best be accomplished with technical assistance from the U.S. Fish and Wildlife Service and may be done as part of the development of the biological assessment in the ESA consultation process. Field offices should consider factors such as:

- The complexity of setting appropriate sideboards.
- How much sideboards would restrict design of specific timber harvests.
- How commonly the specific timber harvests are likely to be implemented (e.g., are the specific timber harvest essential to meeting the ASQ).

See Appendix 4 for examples of approaches to timber sale programmatic analysis.

**Advantages of a programmatic NEPA approach**

- Over the long-term, the programmatic analysis reduces the overall interdisciplinary team workload.
- The BLM can move quickly from completing surveys, conducting fieldwork for timber sales, and issuing timber sale decisions. Shortening the time between completion of the surveys and the timber sale decision reduces the risk of the need to re-survey because survey results are too old or no longer valid. Additionally, this would minimize the risk of lost work in the event of the surveys finding owl occupancy.
- A programmatic approach at a broad geographic scale provides flexibility in identifying timber sales for an annual sale plan (i.e., the BLM can quickly substitute additional stands for harvest if planned harvests need to be dropped, because harvest of the additional stands has already been analyzed).
- Developing a programmatic approach at a broad geographic scale can facilitate consistency with the guidance in Appendix A of the RMPs on management of known owl sites.

**Disadvantages of a programmatic NEPA approach**

- The programmatic analysis may require more up-front interdisciplinary teamwork than sale-by-sale analysis.
- Programmatic analysis is challenging for interdisciplinary team specialists, especially those that have experience only with site-specific analysis.
- Developing appropriate sideboards for some specific timber harvests or specific situations without site-specific and project-specific information may be challenging.
- Sideboards may restrict design of specific timber harvests.

## Batched NEPA Analysis for Timber Sales

An additional option is to prepare an analysis of a batch of timber sales identifying a suite of specific units with specific prescriptions and specific timber sale design features. Batched analysis of timber sales is already a familiar approach for several field offices.

**Advantages of a batched NEPA approach**

- Batched analysis provides some greater efficiency and flexibility than sale-by-sale analysis, especially if the batched analysis includes enough timber sales for multiple years of harvests.
- Interdisciplinary team specialists would have site-specific information which would simplify analysis compared to a programmatic approach.
- Individual timber sales would be designed based on site-specific conditions which would avoid the need for programmatic sideboards.

**Disadvantages of a batched NEPA approach**

- Batched analysis requires more up-front interdisciplinary teamwork than sale-by-sale analysis.
- Batched analysis requires site-specific design and analysis which makes it difficult to move quickly from completing surveys, conducting fieldwork for timber sales, and issuing timber sale decisions. Thus, it would not minimize the risk of lost work in the event of surveys finding owl occupancy.

## ESA Consultation for Timber Sales

As with NEPA analysis, the ESA consultation may be structured for individual projects, batches of projects, or programs of work.

An ESA consultation for a program of work for routine timber sales would evaluate the proposed scope and intensity of the activities that could be authorized under a decision based on a programmatic NEPA analysis, evaluate consistency with the RMP Biological Opinion, and evaluate the project design criteria (PDC) that could be implemented to avoid take. Consultation for a plan of work for routine timber sales, such as those authorized under a decision based on batched or programmatic NEPA analysis, would also establish processes for project-specific monitoring or reporting by the BLM to the U.S. Fish and Wildlife Service as needed. Consultation for a plan of work for routine timber sales should outline under what conditions surveys will be conducted. While the BLM anticipates that pre-project surveys will typically be completed for actions that may affect owls, surveys may not be necessary to complete consultation under some circumstances. Clear descriptions of expected analysis in the consultation documents should prevent conflicts at project-specific monitoring or reporting. Both the survey circumstances and analysis of expectations would be best addressed and agreed to up front by Level 1 teams in the streamlining process.

In a situational management approach to timber sales, PDCs would clearly identify what actions the BLM would implement if owls are not found, and what actions the BLM would implement if owls are found. In some circumstances and for some projects, these choices may be relatively straightforward. For example, for a proposed harvest unit that would remove nesting-roosting habitat within a historic owl site in which the amount of nesting-roosting habitat is currently deficient (see the discussion of habitat availability in core areas and home ranges in Appendix 2). —

- If surveys (or other best available information) determine that owls are not present, the proposed harvest unit would be available for harvest.
- If surveys (or other best available information) determine that owls are present, the proposed harvest unit would be dropped.

In this straightforward example, project-specific monitoring or reporting would be simple, but the identified PDCs would limit management flexibility, and the ability to apply various combinations of harvest prescriptions and site-specific information that may also avoid take (e.g., a “treat and maintain” prescription on all or part of the proposed harvest unit).

Other situational management approaches to timber sales would involve more nuanced situations (i.e., grey areas). For example, a situational management approach might include employing specific harvest prescriptions designed to avoid take within occupied nesting-roosting habitat based on specific conditions within the core area and provincial home range. Such an approach would provide more management flexibility, but would require a more complex set of PDCs and more complicated project-specific monitoring or reporting. The width of this “grey area” between actions that would clearly result in take and actions that would clearly not result in take will be dependent on site and landscape conditions and the specifics of the proposed timber harvest. A situational management approach to timber sales that includes this “grey area” necessarily involves some level of uncertainty at the level of the ESA and programmatic NEPA analysis. As a result, such approaches entail risk that the BLM will expend effort preparing a sale that will later be found to be reasonably certain to take owls. Developing PDCs early in the process and obtaining input from Level 1 teams could help reduce this risk.

## Project-Specific Monitoring or Reporting

An ESA consultation for a plan of work for routine timber sales would include processes for project-specific monitoring or reporting by the BLM to the U.S. Fish and Wildlife Service as needed. Project-specific monitoring or reporting by the BLM would document information, such as the actual location and effects of the project and consistency with the programmatic decision and might potentially include site-specific information on occupancy (such as survey results). The BLM monitoring or reporting would also

confirm that there is no new information that reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in the consultation documents (e.g., validating the information and assumptions in the analysis and consultation documents). For projects in which take of owls is clearly avoided (e.g., where surveys or best available information determine that owls are not present), such validation would be relatively straightforward. Such validation for other projects may require more extensive discussion in the project-specific monitoring or reporting (e.g., for a proposed harvest that would treat and maintain nesting-roosting habitat within an occupied owl site that is currently deficient in habitat). That discussion would likely require more detailed and specific explanation of the PDCs included to avoid take of owls.

The U.S. Fish and Wildlife Service will evaluate the consistency of the project with the consultation documents as needed based on BLM's project monitoring or reporting and any subsequent discussions.

## New Information

Provisions for consideration of new information relative to existing and proposed Federal activities are included in the NEPA and ESA. New information, such as from research, studies, or changed circumstances (i.e. changed conditions on the ground), needs to be considered in the decision making process for proposed actions and for ongoing actions to determine if either NEPA supplementation or re-initiation of ESA consultation is necessary.

For NEPA, the CEQ regulations address "significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts" [40 CFR §1502.9(c)]. The regulation is specific to environmental impact statements, but the BLM policies extend this concept to other levels of NEPA analysis. Ongoing-action NEPA documents will need to be reviewed with respect to the likelihood of "significant new information" warranting supplementation or revision.

The ESA test related to new information is different from that of NEPA. The ESA focuses on "new information," not "significant new information." Under the ESA, re-initiation of consultation is required if "new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered" [50 CFR §402.16(b)]. Thus, while new information may not be significant under the NEPA, it may reveal effects not previously considered under the ESA.

See Appendix 5 for more detailed information on considering new information related to decisions that have been made, but not yet fully implemented.

## Appendix 1 – Examples of Species-Specific Situational Management

The NEPA analyses often include a situational management approach for surveys for project implementation in which specific management actions are conditional on survey results. For example, decisions may describe surveys required for the Bureau special status species and the design features that would be implemented, if species are found. This type of approach is facilitated by existing species-specific, management protocols which can provide a clear description of the management action that the BLM would implement if species are found. For example:

> "Wildlife and botanical clearances will be conducted prior to implementation of timber sales, in accordance with the RMP, as amended. Special status species sites discovered as a result of clearances or pre-disturbance surveys will be managed consistent with the Special Status Species policy."
> http://www.blm.gov/or/districts/eugene/plans/files/DR-FONSI-LTLP-072711.pdf

> "Minimize human interference with the Mulchatna, Northern Alaska Peninsula or Nushagak caribou herds during the following critical periods:
> Calving aggregations (May 15 to June 15),
> Post calving aggregations (June 15 to July 15) or
> Insect relief aggregations (June 15 to August 31).
> If no feasible alternative exists, qualified personnel will conduct a preliminary site survey within the two week period prior to an activity's projected start date to establish caribou presence. No activity will commence prior to May 1 in suspected caribou calving habitat or June 1 in suspected post-calving or insect relief caribou habitat. If caribou are present, temporary activities will be delayed until caribou have left the habitat."
> http://www.blm.gov/style/medialib/blm/ak/aktest/planning/bay_prop_RMP_and_final_EIS.Par.34415.File.pdf/Appendix_A_ROPs_Stips.pdf

## Appendix 2 – Evaluation of Take[1] Potential

This appendix summarizes the information available to support the consistent application of science to the analysis of potential effects of timber harvest on owls. Consistent use and interpretation of science does not mean, nor does it support, absolute thresholds for habitat that always equate to take/take avoidance. However, where there are similar biological and physical conditions and similar types of impacts, the determination of take probability would typically be consistent.

The considerations and information sources provided here are not substantially different from what is currently being used by multiple Level 1 teams in developing biological assessments and biological opinions. This section does not represent a specific methodology or direction, but does provide a summary of the best available information that should be considered during analysis. It does not proscribe an analytical outcome based on habitat amount, distribution, or harvest treatment. Habitat quantity, juxtaposition, and treatment at the individual site will inform the actual likelihood of take through site specific analysis. The assessment of effects needs to consider not just the effects to the treated stands but also put those effects into context of entirety of an owl's "habitat." Until and unless additional information is developed warranting change, the provincial home range/core-use area retain their usefulness in defining the extent and spatial importance of an owl's habitat, mainly because the average quantity of "habitat" within those areas has been shown to be associated with occupancy and reproduction. As with assessing stand function, it is important to remember that the estimate of habitat quantities within the provincial home range/core-use area are derived mean quantities, not absolute thresholds. Any estimate of effect needs to take into account variance in actual home range/core areas estimated from empirical studies and the composition and arrangement of habitat elements. This is consistent with past and expected future Level 1 team analysis.

That take can result from habitat alteration is well established, but it is important to remember that habitat is not a single element but the result of the spatial arrangement, quantity, and configuration of those elements.

The U.S. Fish and Wildlife Service is responsible for the ultimate determination in a biological opinion of whether and how much take should be exempted in an incidental take statement [50 CFR §402.14(g)]. However, the BLM has extensive experience assessing effects and working with the U.S. Fish and Wildlife Service in Level 1 teams. This section is a summary of the current practices and science that was used in recent ESA effects/take analysis by the BLM and the U.S. Fish and Wildlife Service.

Survey history for owls may be the primary, but not the only source of best available information in determining spotted owl site occupancy at the time of implementation. For example, other sources of information could include site history (including history of re-occupancy and habitat availability), quantity, quality, and distribution. Survey results may be used in conjunction with site history data and habitat to inform analyses in determining if occupancy is reasonably certain at the time of implementation. Level 1 teams are encouraged to reach agreements on the use of this information in consultation. In cases where surveys are not current when consultation occurs, Level 1 teams are encouraged to evaluate habitat information, history of occupancy, barred owl presence, habitat models (e.g., Glenn *et al*. 2016), and other information as appropriate to inform the likelihood of occupancy.

A well-established analytical approach to analyze the effects of proposed activities on the owl is based on the extent, duration, and timing of habitat-altering activities, and how those alterations are likely to affect

[1] The ESA defines take as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" 16 U.S.C. 1532(19). The definition of harm is "an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering" 50 CFR 17.3.

owl nesting, roosting, foraging, and dispersal behavior based on known spatial and habitat use relationships exhibited by the owl (see Lehmkuhl and Raphael 1993; USDI BLM *et al*. 1994; Meyer *et al*. 1998; Courtney *et al*. 2004). The anticipated amount of forest habitat likely to be used by owls considers the known range of habitat conditions used by owls for nesting, roosting, and foraging (see Thomas *et al*. 1990; Courtney *et al*. 2004). In addition, the basis for a finding that a proposed action is likely to significantly impair the breeding, feeding, sheltering, and/or dispersal of affected owls relies on the scientifically-recognized range of habitat conditions that are known to adequately provide for owl-life history requirements.

Owls exhibit clear, consistent patterns of habitat association, and these patterns can provide the foundation for assessing the potential effects caused by land management activities. In the 1990 Conservation Strategy for the Northern Spotted Owl, the Interagency Scientific Committee (Thomas *et al*. 1990) stated that:

> "With the exception of recent studies in the coastal redwoods of California, all studies of habitat use suggest that old-growth forests are superior habitat for northern spotted owls. Throughout their range and across all seasons, spotted owls consistently concentrated their foraging and roosting in old-growth or mixed-age stands of mature and old-growth trees.... Structural components that distinguish superior spotted owl habitat in Washington, Oregon, and northwestern California include: a multilayered, multispecies canopy dominated by large (>30 inches diameter breast high (DBH)) conifer overstory trees, and an understory of shade-tolerant conifers or hardwoods; a moderate to high (60-80 percent) canopy (cover or closure depending on the study) closure; substantial decadence in the form of large, live coniferous trees with deformities- such as cavities, broken tops, and dwarf mistletoe infections; numerous large snags; ground cover characterized by large accumulations of logs and other woody debris; and a canopy that is open enough to allow owls to fly within and beneath it."

Fifteen years later, the conclusions of the Interagency Scientific Committee were echoed in the Scientific Evaluation of the Status of the Northern Spotted Owl (Courtney *et al*. 2004), which found that the habitat attributes identified by Thomas *et al*. (1990) remain important components of owl habitat. Notably, positive relationships were found with the aforementioned attributes whether the samples of owl and random locations were within old-growth forest, non-old growth forest, National Parks, public land, or private land. In 2011, the Revised Recovery Plan for the Northern Spotted Owl (USDI FWS 2011) again reiterated the association of owls with older forest conditions, stating, "Spotted owls generally rely on older forested habitats (Carroll and Johnson 2008) because such forests contain the structures and characteristics required for nesting, roosting, and foraging (NRF)." Forested stands with high canopy cover also provide thermal cover (Weathers *et al*. 2001) and protection from predators (Franklin *et al*. 2000).

**Owl Spatial Use of Forest Landscapes**

A major advance in our understanding of owl habitat relationships from Thomas *et al*. (1990) to the present is that we now have a much better understanding of the spatial scale of habitat selection (see Hunter *et al*. 1995; Meyer *et al*. 1998; Zabel *et al*. 2003) and the relationships of habitat to owl fitness (Franklin *et al*. 2000; Olson *et al*. 2004; Dugger *et al*. 2005). Evaluating effects to territorial organisms is typically spatially explicit and at a spatial scale that corresponds to the movement and activity patterns of the individual(s) occupying the territory (or territories). Owls are territorial raptors that range widely in search of prey but are 'anchored' during the breeding season to a nest site (Rosenberg and McKelvey 1999). That is, owls are a central-place forager. Foraging close to the nest reduces travel time and energetic expenditures of adults and also increases the ability of the adults to remain nearby and protect their young. Several studies have shown that owls optimize selection of their nest sites to maximize the amount of older forest habitat close to the nest (see Ripple *et al*. 1991; Ripple *et al*. 1997; Swindle *et al*. 1999; Perkins 2000) in addition to selecting habitat on a larger landscape basis (Ripple *et al*. 1997; Swindle 1997). On that basis, evaluations of owl spatial use of an area and habitat are most meaningfully conducted at two spatial scales: the provincial home range/core-use area and recognizing that habitat selection at a larger home range scale is likely dependent on the smaller core area (see Johnson 1980 for hierarchy of habitat selection).

The home range is the "area traversed by the individual in its normal activities of food gathering, mating, and caring for young" (Burt 1943, p. 351). Within home ranges, areas receiving concentrated use, typically surrounding the nest site and favored foraging areas, are called core areas (Bingham and Noon 1997). Establishing the exact spatial extent of an owl's home range and core area based on relative use within a home range typically requires use of radio-telemetry. Because of the intensity and high cost of radio-telemetry, action agencies are not able to conduct this type of study for specific projects. Therefore, for the purposes of assessing a project's potential impacts to the owl, the U.S. Fish and Wildlife Service approximates circles of similar size to the provincial median home range and core-use area estimates of owls (see home range estimates in Thomas *et al*. 1990 and reaffirmed in Courtney *et al*. 2004), centered on owl nest sites or activity centers (see below).

There are numerous analytical techniques for estimating home range sizes based on animal locations (reviewed in Powell 2000). For estimating median-annual, home range size of owl pairs in Oregon (and elsewhere in the owl's range), the estimator typically used was the minimum convex polygon (MCP) method (Thomas *et al*. 1990; USDI FWS 1992). Because the MCP estimates are generally large (as compared to other methods), they provide relatively conservative values on which to base the outer habitat-analysis area in that they include distant but likely important patches of habitat in such home ranges.

Resources, such as food and breeding and resting sites, can be patchily distributed in heterogeneous landscapes such as those prevalent throughout the Northwest Forest Plan provinces. In such landscapes, animals are likely to disproportionately use areas that contain relatively high densities of important resources (Powell 2000), with concentrated use close to their nests. These disproportionately used areas are referred to as "core areas" (Bingham and Noon 1997). Thomas *et al*. (1990) found that amounts of habitat within 0.7 miles (986 acres) of owl activity centers were important to owl life history functions, and that the amount of habitat around nest sites was significantly greater than the amount of owl habitat in random circles. The findings of Thomas *et al*. (1990) illustrate the importance of the amount of habitat within an owl territory to support the life history requirements of the owl. The results of subsequent studies (see below) have also indicated that a 0.5-mile radius circular area encompassing 500 acres around owl activity centers is likely a more appropriate scale at which to evaluate the amounts of habitat required by breeding owls (USDI FWS 2009; USDI FWS 2011 Appendix B). These studies relied on three primary sources of information to support the 500-acre core area size: (1) the distribution of locations of radio-telemetered owls; (2) the territorial spacing patterns of owls; and (3) the results of studies comparing relative habitat selection by owls at different scales.

Currently, the best available information supports utilizing the documented owl spatial use patterns of home range and core-use areas to inform potential project effects to the species. However, because of the impracticality of conducting radio-telemetry on each individual owl potentially affected, the U.S. Fish and Wildlife Service uses circles as surrogates for approximating owl home range and core to inform impacts to the species. Owls may adjust the shape of their home ranges to encompass as much older forest habitat as possible (Carey *et al*. 1992). As such, the use of circles may not correspond exactly with the areas used by owls and may be more defined by other factors such as topographic features (e.g., drainages), abundance and availability of prey species, and the distribution and/or abundance of competitors and predators (Anthony and Wagner 1998; Courtney *et al*. 2004). However, the practice of using circles has a biological basis (Lehmkuhl and Raphael 1993) and has been utilized by many researchers (Thomas *et al*. 1990; Ripple *et al*. 1991; Lehmkuhl and Raphael 1993; Ripple *et al*. 1997; Swindle *et al*. 1999; Perkins 2000; Franklin *et al*. 2000; Olson *et al*. 2004; Dugger *et al*. 2005; see summary in Courtney *et al*. 2004) by providing a uniform method for quantifying (comparing/contrasting) owl habitat. Use of circles, as opposed to other shapes (e.g., squares or rectangles) imposes no bias on what is included or excluded for analysis. The use of circles also seems appropriate for species, like the owl, characterized as a "central place species" and provides a simple, unbiased measure of habitat availability at multiple ecologically- relevant scales surrounding owl sites. The use of circles, as described herein that correspond to MCP estimates (and used interchangeably) should be large enough to include habitat to meet all major life history needs and include

areas important to both members of most pairs. Level 1 teams have agreed to some exceptions to using circles, including analyses based on site-specific information on habitat type, quality, and spatial arrangement.

Based on the median MCP home range size estimate for owl pairs, the following estimates by Northwest Forest Plan Province help inform an owl spatial analysis for Oregon: Coast Ranges Province = 4,524 acres or a circle with a 1.5-mile radius; West Cascades Province = 2,895 acres or a circle with a 1.2-mile radius; and the Klamath Province = 3,398 acres or a circle with a 1.3- mile radius. Within a home range, the smaller core-use area estimate of 500 acres or a circle with a 0.5-mile radius inform the owl core-use area analysis (Thomas *et al*. 1990; USDI FWS 1992; Carey *et al*. 1992; Anthony and Wagner 1998; Irwin *et al*. 2000; Courtney *et al*. 2004; Glenn *et al*. 2004; USDI FWS 2011). For purposes of analysis, except as indicated in the example above, the core/home range area circle will be centered on an owl activity center that represents the area that owls are likely to use for nesting and foraging in any given year. In situations where there is local information available on home range and core-use areas, those estimates should be given consideration for use.

Spotted owl landscape use is influenced by abiotic features, which need to be considered in the evaluation of habitat use and effects. For example, best available information suggests that aspect, elevation, and the position of habitat on the slope are contributing factors to owl use of landscapes.

Best available information suggests that the presence and distribution of barred owls may affect habitat quality and site occupancy by spotted owls (Wiens 2012; Yackulic *et al.* 2012; Dugger *et al.* 2016). As such, it is appropriate to factor in information on barred owl occupancy relative to spotted owl known sites in the evaluation of spotted owl site occupancy and potential effects due to habitat modification.

**Habitat Availability in Owl Core Areas and Home Ranges**
Best available information indicates that owl sites that are occupied over the long-term are positively associated with mosaics of forest habitat at the core-use area and provincial home range scales that are capable of providing the resources necessary to meet the essential life functions of individual owls.

**Nest Patch**
As central place foragers, nesting owls are likely most sensitive to activities that occur near the nest site. The "nest patch" is generally considered the area within 300 m (~28 ha) of the actual nest. Stand conditions within this radius are indicative of nesting (Swindle *et al*. 1999) and the mean area used by juveniles before dispersal (Miller 1989). Level 1 teams have agreed to some exceptions to using a 300 m circle, including analyses based on site-specific information on habitat type, quality, and spatial arrangement. Nest patches are usually associated with older forest; however, young forest may also be an important component due to their proximity to the nest site and potential usage by spotted owls (Glenn et al. 2004, p. 48). Relatively minor changes in stand composition or shape of a nest patch may result in substantial reductions in the likelihood of occupancy and reproduction of the territory. (Swindle *et al.* 1999; Perkins 2000).

**Core Area**
Recently developed habitat-fitness (see below) and landscape models and other publications have demonstrated the validity of the core-use area and the importance of having sufficient amounts of NRF habitat within owl core areas to adequately provide for owl survival and reproduction, and access to prey (Franklin *et al*. 2000; Olson *et al*. 2004; Dugger *et al*. 2005; Zabel *et al*. 2003). Best available information to date indicates that owl survival and fitness are positively correlated with large patch sizes of older forest or large forest patches containing a high proportion of older forest (Franklin *et al*. 2000; Olson *et al*. 2004; Dugger *et al*. 2005). Habitat-based fitness or habitat fitness potential (HFP) is the "fitness conferred on an individual occupying a territory of certain habitat characteristics" (Franklin *et al*. 2000). The HFP is function of both the survival and reproduction of individuals within a given territory. For example, the data sets analyzed by Franklin *et al*. (2000) were re-analyzed to evaluate the relationship between HFP and the simple proportion of older forest within owl core areas. The results of that analysis (USDI FWS 2007,

Appendix D), indicate a quadratic relationship between owl HFP and older forest conditions, with optimum HFP occurring when approximately 50 percent of the estimated core area consisted of older forest (Franklin *et al*. 2000). More than half (55 percent) of the high-quality (with a HFP greater than one) owl territories had core areas comprised of 50 to 65 percent older forest. In a similar study in southern Oregon, Dugger *et al*. (2005) found that owl HFP was positively related to the proportion of older forest in the core area, although the strength of the relationship decreases with increased proportions. Roughly 72 percent of core areas with a HFP greater than 1.0 had more than 50 percent older forest; whereas core areas with a HFP of less than 1.0 never contained more than 50 percent older forest.

Olson *et al*. (2004, pp. 1049-1050) concluded that their results indicate that while mid-seral and late-seral forests are important to owls, a mixture of these forest types with younger forest and non-forest may be best for owl survival and reproduction in their study area. In a large-scale demography modeling study, Forsman *et al*. (2011, pp. 1-2) found a positive correlation between the amount of habitat and recruitment of young. Dugger *et al*. (2005, pp. 873-874) concluded that they found no support for either a positive or negative direct effect of intermediate-aged forest—that is, all forest stages between sapling and mature, with total canopy cover greater than 40 percent—on either the survival or reproduction of owls.

Collectively, researchers (Hunter *et al*. 1995; Ripple *et al*. 1997; Gutiérrez *et al*. 1998; Meyer *et al*. 1998; Franklin *et al*. 2000; Dugger *et al*. 2005) have reported a wide range (ca. 35 to 60 percent) of mean proportions of older forest at the core area scale around owl nests in southwest Oregon and northwest California. It is difficult to assess how much of this variation was due to differences in ecological setting, spatial scale, habitat classification, and individual variation among owls. Nonetheless, the central tendency of these results was roughly 50-60 percent older forest habitat within owl core-use areas. The best available information suggests that older forest is more likely than other vegetation classes to provide the owl with structures for perching and nesting, a stable, moderate microclimate at nest and roost sites, and visual screening from both predators and prey.

**Annual Home Range**

Bart (1995) evaluated the suggestion in the 1992 draft recovery plan for the owl (USDI FWS 1992) that at least 40 percent of the estimated home range be retained as habitat. Using demographic data from throughout the owl's range including Oregon, Bart (1995) calculated that owl populations are stable when the average proportion of NRF habitat in the home range is 30 to 50 percent. Olson *et al*. (2004) found for their Oregon Coast Ranges study area that mid and late-seral forest is important to owls, but also found that a mixture of these forests with early seral forest improved owl productivity and survival. Owl demography and the presence of owls appear to be positively associated with an intermediate amount of horizontal heterogeneity in forest habitat at the home range scale (Schilling *et al*. 2013); findings reported in more recent papers (see USDI FWS 2009) have been consistent with those of Bart (1995).

**Site Occupancy**

Habitat-based assessments have been used in various studies to estimate the presence (occupancy) of breeding owls; these tools are important for evaluating the species-habitat relationships. Bart (1995) reported that occupied owl core areas contained at least 30 to 50 percent mature and old growth forest and owl demographic performance, particularly occupancy, increases with increasing amounts of NRF habitat in the core area. Meyer *et al*. (1998) examined landscape indices associated with owl sites versus random plots on BLM-managed lands throughout Oregon. Across provinces, landscape indices highly correlated with the probability of owl occupancy included the percent of older forest (approximately 30 percent) within the 500 acres (analogous to a core area) surrounding the site (and this predictive value decreased with increasing distance) and that territory occupancy decreased following the harvest of NRF habitat in the vicinity of the affected core area. Zabel *et al*. (2003) found for their northwest California study area that the highest probability of owl occupancy occurred when the core area is comprised of 60 - 70 percent nesting/roosting habitat. Stepping up to the larger home range scale, Thomas *et al*. (1990), Bart and

Forsman (1992), Bart (1995), Olson *et al*. 2004, and Dugger *et al*. (2005) suggest that when owl home ranges are comprised of less than 40 to 60 percent NRF habitat, they were more likely to have lower occupancy and fitness.

Many different combinations of forest habitat structure and amount at various spatial scales may support viable owl territories sufficient for the survival and reproduction of individual owls. Despite consistent patterns of habitat selection by owls, structural conditions of forest habitats occupied by owls are highly variable. However, overall the best available information suggests that (1) the probability of owls occupying a given patch of forest habitat is increased when core areas contain a range of forest habitat conditions that support the essential life history requirements of individual owls; and (2) the survival and fitness of owls are positively correlated with larger patch sizes of older forest or larger patches of forest habitat with a high proportion of older forest (Franklin *et al*. 2000; Olson *et al*. 2005; Dugger *et al*. 2005).

**Spotted Owl Nesting, Roosting, Foraging Habitat Selection**
Forsman *et al*. (1984, pp.15-16) reported that spotted owls have been observed in the following forest types: Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), grand fir (*Abies grandis*), white fir (*A. concolor*), ponderosa pine (*Pinus ponderosa*), Shasta red fir (*A. magnifica shastensis*), mixed evergreen, mixed conifer hardwood (Klamath montane), and redwood (Sequoia sempervirens). The upper elevation limit at which spotted owls occur corresponds to the transition to subalpine forest, which is characterized by relatively simple structure and severe winter weather (Forsman 1975; Forsman *et al*. 1984).

Spotted owls nest almost exclusively in trees. Like roosts, nest sites are found in forests having complex structure dominated by large diameter trees (Forsman *et al*. 1984; Hershey *et al*. 1998). Even in forests that have been previously logged, spotted owls select forests having a structure (i.e., larger trees, greater canopy cover) different than forests generally available to them (Folliard 1993; Buchanan *et al*. 1995; Hershey *et al*. 1998). In the western Cascades of Oregon, 50 percent of spotted owl nests were in late-seral/old-growth stands (greater than 80 years old), and none were found in stands of less than 40 years old (Irwin *et al*. 2000).

Roost sites selected by spotted owls have more complex vegetation structure than forests generally available to them (Barrows and Barrows 1978; Forsman *et al*. 1984; Solis and Gutiérrez 1990, pp. 742-743). These habitats are usually multi-layered forests having high canopy cover and large diameter trees in the overstory.

Foraging habitat is the most variable of all habitats used by territorial spotted owls (Thomas *et al*. 1990; USFWS 2011). Descriptions of foraging habitat have ranged from complex structure (Solis and Gutiérrez 1990) to forests with lower canopy cover or closure and smaller trees than forests containing nests or roosts (Gutiérrez 1996). Foraging habitat for owls provides a food supply for survival and reproduction. Foraging activity is positively associated with tree height diversity (North *et al*. 1999), canopy cover or closure (Irwin *et al*. 2000; Courtney *et al*. 2004), snag volume, density of snags greater than 20 in (50 cm) DBH (North *et al*. 1999; Irwin *et al*. 2000; Courtney *et al*. 2004), density of trees greater than or equal to 31 in (80 cm) DBH (North *et al*. 1999, p. 524), volume of woody debris (Irwin *et al*. 2000, pp. 179-180), and young forests with some structural characteristics of old forests (Carey *et al*.1992; Irwin *et al*. 2000). Spotted owls select old forests for foraging in greater proportion than their availability at the landscape scale (Carey *et al*. 1992; Carey and Peeler 1995; Forsman *et al*. 2004, pp. 372-373), but will forage in younger stands with high prey densities and access to prey (Carey *et al*. 1992, p. 247; Rosenberg and Anthony 1992, p. 165; Thome *et al*. 1999).

Note that Zabel *et al*. (2003) for the Klamath Province found that the probability of occupancy by owls was highest when the core area scale contained some foraging habitat, as well nesting-roosting habitat. This result suggests that horizontal heterogeneity in the core should be partially provide by a range of forest

conditions suitable for use by owls, dominated by older forest conditions, not simply the juxtaposition of suitable and unsuitable habitat.

In the Coast Ranges, Western Oregon Cascades and the Olympic Peninsula, radio-marked owls selected old-growth and mature forests for foraging and roosting and used young forests less than predicted based on availability (Forsman *et al*. 1984; Carey *et al*. 1990; Thomas *et al*. 1990; Forsman *et al*. 2005). Glenn *et al*. (2004) studied owls in young forests in western Oregon and found little preference among age classes of young forest.

Habitat use is influenced by prey availability. Ward (1990) found that owls foraged in areas with lower variance in prey densities (that is, where the occurrence of prey was more predictable) within older forests and near ecotones of old forest and brush seral stages. Zabel *et al*. (1995) showed that owl home ranges are larger where flying squirrels (*Glaucomys sabrinus*) are the predominant prey and smaller where wood rats (*Neotoma* spp.) are the predominant prey.

**Dispersal Habitat**

Dispersing owls, using dispersal habitat, are essential to maintaining stable populations by filling territorial vacancies when resident owls die or leave their territories (colonization phase), and to providing adequate gene flow across the range of the species (transience phase). The effects analysis for owl dispersal habitat considerations is informed by landscape conditions, as suggested by Thomas *et al.* (1990) along with Lint *et al*. (2005) and Davis *et al*. (2016). Typical dispersal-only habitat is characterized as forest stands less than 80 years old, of simple structure, and providing some foraging structure and prey base for owls as they disperse across the landscape (Miller *et al*. 1997; Courtney *et al*. 2004) with adequate tree size and canopy to provide protection from avian predators (USFWS 2011). However, dispersal habitat not only includes the forests as previously described, but also forests greater than 80 years old which provides better dispersal conditions due to stand structure and available prey (Miller *et al*. 1997; Courtney *et al*. 2004; Sovern *et al*. 2015). Although, as Buchanan (2004, p. 1,341) noted, the stand- and landscape-level attributes of forests needed to facilitate successful dispersal may not have been thoroughly evaluated. An assessment of dispersal habitat condition was recommended on the quarter-township scale by Thomas *et al*. (1990); the U.S. Fish and Wildlife Service has subsequently used fifth-field watersheds or larger landscapes for assessing dispersal habitat conditions because watersheds or provinces offer a more biological meaningful way to conduct the analysis (see Davis *et al*. 2011). Forsman *et al*. (2002, p. 22) found that owls could disperse through highly fragmented forest landscapes.

**Biological Opinion Examples**

As was summarized above, there is variation in the amount, composition, and arrangement of stands associated with occupancy and reproduction by owls. However, there is consistency between studies in the amount of NRF habitat at the provincial home range/core-use area scale below which occupancy and reproduction becomes unlikely. Using this information and applying it to site-specific conditions and proposed harvest prescription Level 1 teams have largely coalesced around actions and conditions that would be considered likely to result in take that are consistent with concepts expressed above. The following example BOs all started with the premise the activity centers at or below minimum average habitat levels associated with occupancy would be at risk from further removal or degradation of habitat. Site-specific information may have resulted in different findings, but the analytical questions around quantity, configuration, and ownership of habitat and the location, extent and magnitude of proposed harvest activities are similar.

Lower Grave Timber Harvest Project (Reference Number 01EOFW00-2015-F-0028). The BO analyzed the entirety of the conditions at an occupied activity center and the potential effects of a putative treat and maintain prescription and determined that take was reasonably certain to occur. Treatments intended to maintain habitat function need to be tailored to the stand affected and the current condition of the occupied territory.

Nedsbar Forest Management Project (Reference # 01EOFW00-2016-F-0283). Detailed discussion of how the Level 1 team evaluated impacts to owls based on the best information regarding the average conditions known to support occupancy and reproduction tempered with regional and site-specific analysis.

Soup Creek Variable Retention Harvest Project (Reference #: 01EOFW00-2014-F-0053). The Soup Creek BO provides an example where in the absence of complete surveys a determination of No Take was supported with an analysis of amount and juxtaposition of habitat using information specific to the area such as nearest neighbor distances derived from the nearest demography study area.

NOTE: As stated above, this information summarizes scientific information and analysis contained in recent biological assessments and biological opinions. The U.S. Fish and Wildlife Service participated in preparing Appendix 2 as technical assistance only. Nothing in it should be interpreted as policy direction by the U.S. Fish and Wildlife Service. In implementing the RMPs, the BLM should use the best scientific information available at the time and applicable to the specific factual circumstances.

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## Appendix 3 - Programmatic and Batched NEPA Analyses

**Approaches to Programmatic NEPA Analysis**

Programmatic NEPA analysis can be more challenging because of the lack of site-specific information and project-specific details. There are three general approaches to conducting programmatic analysis:

- Keep the analysis general and conditional – actual effects would depend on specific actions and specific conditions without identifying which actions and which conditions would result in which effects. This approach is sometimes valuable for selecting a broad strategy, but typically requires additional NEPA analysis for project-specific decisions.
  - NEPA Best Practices: Prepare the programmatic NEPA document to make a choice about a strategic approach. Tier NEPA documents for project-specific decisions to the programmatic decision.
  - Level 1 Consultation Best Practices: Consultation on a program of work may be helpful and may simplify consultation at the project level, but project-level consultation would be necessary.
- Make analytical assumptions about a maximum level of activity – effects for individual actions would be covered as long as the cumulative total of activities or effects remains below a specified threshold.
  - NEPA Best Practices: Complete a DNA to identify location and timing of projects as the programmatic decision is implemented. The DNA would also verify the application of project design features, assess if there is new information or changed circumstances, and verify that the type and level of activity is in accordance with what was analyzed in the programmatic NEPA.
  - Level 1 Consultation Best Practices: Consult on the program of work. If take can be assessed at level of the program of work (or no take would occur), project-level consultation would typically be unnecessary.
- Make analytical assumptions about typical activities – effects for individual actions would be covered as long as the individual action and specific conditions are substantially similar to those analyzed.
  - NEPA Best Practices: Complete a DNA to identify location and timing of projects as the programmatic decision is implemented. The DNA would also verify the application of project design features, assess if there is new information or changed circumstances, and verify the action and site-specific conditions are substantially similar to what was analyzed in the programmatic NEPA.
  - Level 1 Consultation Best Practices: Consult on the program of work. If take can be assessed at the level of the program of work (or no take would occur), project-level consultation would typically be unnecessary.

**Examples of Programmatic NEPA Analyses for Programs of Work**

Programmatic NEPA analyses can be structured around an entire program of work. In such analyses, the proposed action analysis may be truly programmatic in nature; that is, the proposed action describes the type of actions, typical design features, and the amount and extent of activities without identifying specific locations and timing of actions.

For example, several districts have prepared district-wide programmatic EAs for aquatic restoration, identifying categories of actions (instream habitat restoration, road and culvert actions, and riparian treatments), project design features, and typical and maximum annual amounts of restoration actions without identifying specific project locations or timing. The ESA consultation was provided by the programmatic ARBO consultation.
http://www.blm.gov/or/districts/salem/plans/files/salem_aqua.pdf
http://www.blm.gov/or/districts/eugene/plans/files/Restoration_EA.pdf
http://www.blm.gov/or/districts/roseburg/plans/files/AquaticRestEA.pdf
http://www.blm.gov/or/districts/medford/plans/files/Aquatic_Restor_EA.pdf

The seed orchards in western Oregon prepared programmatic environmental impact statements for integrated pest management, identifying pest management methods, without identifying specific project locations, or timing. The Records of Decision described that the BLM would complete a DNA for individual or groups of actions (such as an annual program of work) and anticipated that most or all actions would be implemented without additional NEPA analysis. An ESA consultation included issuance of a biological opinion including an incidental take statement from National Marine Fisheries Service (NMFS). The biological opinion stated that it was not possible to quantify take. The incidental take statement used water concentrations of pesticides as a surrogate. The BLM provides NMFS with annual comprehensive monitoring and operation reporting.
http://www.blm.gov/or/districts/medford/plans/files/provolt_ipm_final_eis_acc.pdf

The West Eugene Wetlands RMP identified habitat restoration and maintenance actions that would occur within specific land use allocations in accordance with management direction, without identifying specific project locations or timing. The Record of Decision described that the BLM would complete a DNA for individual or groups of actions (such as an annual program of work) and anticipated that most or all actions would be implemented without additional NEPA analysis. The ESA consultation included issuance of a biological opinion including an incidental take statement from the U.S. Fish and Wildlife Service. The biological opinion stated that it was not possible to quantify take in terms of numbers of individuals. The incidental take statement used acres of habitat area treated as a surrogate. The BLM provides the U.S. Fish and Wildlife Service with annual project implementation and monitoring reports of activities.
http://www.blm.gov/or/districts/eugene/plans/files/wew-rod.pdf

**Examples of Programmatic Analyses for Suites of Actions**
Programmatic NEPA analyses can also be structured around a suite of proposed actions in a specific geography. In such analyses, the proposed action may either describe specific actions, in specific locations, with specific timing, or describe types of actions and the conditions under which they would be implemented.

Several field offices have prepared programmatic analyses for all anticipated actions within a watershed, including forest management, road management, and habitat restoration actions. These analyses describe the types of actions and the typical conditions under which they would be implemented, and analyze the effects based on typical project design features and typical levels of activity. The BLM issues individual project decisions (such as individual timber sales) after completion of a DNA. The ESA consultation has typically, but not always, included issuance of a biological opinion on these programmatic decisions. In some instances, consultation has been deferred to the project level (e.g., consultation with NMFS on commercial thinning in the Upper Siuslaw LSR ROD).
http://www.blm.gov/or/districts/eugene/plans/files/edo_us_lsr_rods.pdf
http://www.blm.gov/or/districts/eugene/plans/files/DR-FONSI-LTLP-072711.pdf
http://www.blm.gov/or/districts/roseburg/plans/files/UpUmpDR.pdf

**Examples of Batched Actions**
Field offices have prepared analyses for batches of timber sales and restoration actions in specific locations. These analyses are not actually programmatic, in that they identify specific actions in specific locations. They represent a compilation of project-specific analyses, which may facilitate cumulative effects analysis. The ESA consultation for the individual actions under these batched decisions has typically been conducted as part of the regular batched consultations.
http://www.blm.gov/or/districts/coosbay/plans/files/UmpquaSawyerEA.pdf
http://www.blm.gov/or/districts/eugene/plans/files/2015_09_23_Lost_Creek_EA.pdf

## Appendix 4 - Approaches to Timber Sale Programmatic NEPA Analysis

The following are hypothetical examples of how timber sales could be addressed in a programmatic NEPA analysis.

Programmatic NEPA Analysis Example 1: the proposed action in a timber sale programmatic analysis would describe the stand or landscape conditions and under which we would implement commercial thinning and the conditions under which we would implement regeneration harvest, and identify a range of acres for each treatment per year. The proposed action would set sideboards for timber harvest design, such as:

- silvicultural prescriptions under specific stand conditions
- yarding specifications or limitations under specific seasonal, slope, or soil conditions
- road design specifications or limitations

The proposed action would stipulate that owl surveys would occur within habitat prior to implementation of treatments, and that timber harvest of nesting-roosting habitat would occur only outside of home ranges currently occupied by owls.

Programmatic NEPA Analysis Example 2: the proposed action in a timber sale programmatic analysis would describe the stand or landscape conditions under which we would implement commercial thinning, the conditions under which we would implement selection harvest, and the conditions under which we would implement regeneration harvest, and identify a range of acres for each treatment per year. The proposed action would set sideboards for timber harvest design, such as:

- silvicultural prescriptions under specific stand conditions
- yarding specifications or limitations under specific seasonal, slope, or soil conditions
- road design specifications or limitations

The proposed action would stipulate that owl surveys would occur within nesting roosting habitat prior to implementation of treatments, and that—

- timber harvest of nesting-roosting habitat would occur outside of home ranges currently occupied by owls, or
- timber harvest of nesting-roosting habitat within home ranges currently occupied by owls would treat and maintain that habitat.

Under such examples, the BLM could complete consultation on a program of work for routine timber sales, issue a decision on the management approach, and then make individual timber sale decisions based on the completion of a Determination of NEPA Adequacy (DNA) and monitoring or reporting to the U.S. Fish and Wildlife Service. The DNA would document the BLM determination that the design of the timber sale is consistent with the sideboards described in the programmatic NEPA analysis, and that the site conditions and effects are adequately analyzed in the programmatic NEPA analysis.

The BLM could still implement timber sales that are not covered by the programmatic NEPA analysis, based on project-specific NEPA analysis, consultation, and decision-making. That is, such a programmatic NEPA analysis would only provide NEPA compliance for the timber harvests addressed by the programmatic analysis, but it would not preclude other timber harvests.

## Appendix 5 - Considering New Information in NEPA Documents and ESA Consultation

Appropriate changes to NEPA documents should be made in accordance with the CEQ regulations relating to significant new information [40 CFR §1502.9(c)], and the BLM NEPA Handbook Sections 5.3.1 and 5.3.2, pp. 29-30. Similarly, appropriate changes with respect to ESA Section 7 consultation should be made in accordance with the ESA regulations relating to re- initiation of formal consultation (50 CFR §402.16). Note: Questions 1 - 6 pertain to NEPA and Questions 7 – 11 pertain to ESA.

**1) Does the BLM have discretion or control over the ongoing action?**

- NO – no further action or analysis necessary. A finding of "no discretion or control" could be documented for the record using a Determination of NEPA Adequacy (DNA).
- YES – go to 2.

**2) Is the information new (i.e., was this fact about the environmental relationships considered when the original decision was made)?**

- NO – no further NEPA action or analysis necessary. A finding of "no new information" should be documented for the record using a DNA. Describe the rationale and provide specific references to the NEPA analysis and Biological Assessment. Go to 7.
- YES – go to 3.

**3) Is the new information relevant to environmental concerns for this action (i.e. describes environmental relationships pertaining to direct, indirect or cumulative effects of management activities on components of the environment)?**

- NO – no further NEPA action or analysis necessary. A finding of "non-relevance" should be documented for the record using a DNA. Go to 7.
- YES – go to 4.

**4) Does the new information tell you something substantially different about effects of the ongoing action (i.e. they would change the context of intensity of the environmental effects such that basic assumptions, analyses, and conclusions are substantially altered)? For example, are resource conditions substantially different than were assumed in the original analysis?**

- NO – document "no significant new information under NEPA" using a DNA and go to 7.
- YES – go to 5.

**5) Does the magnitude of changed effects require a different level of NEPA analysis than was originally applied? (See explanation below)**

- NO – supplement or modify existing NEPA analysis to reflect the significant new information/circumstances and go to 6.
- YES – complete new level of NEPA analysis and documentation and go to 6.
- *[The questions to be answered depend on the original NEPA document:*
- *Environmental Impact Statement: The CEQ regulations ask whether the information is significant. New information is significant if it changes the context or intensity of the environmental effects to the extent that basic assumptions, analyses, and impact conclusions are substantially altered. In such cases, a Supplemental EIS is warranted to provide additional opportunity for public comment and for reconsideration of impacts and public comments by the decision maker. The criteria in 40 CFR §1508.27 may be used in this determination.*
- *<u>Environmental Assessment</u>: Are the differences in effects such that the effects of the action "may be" significant? If so, preparation of an EIS is required.*
- *<u>Categorical Exclusion</u>: Since the nature of the action has not changed, it would still be on the list of categorically excluded actions. However, the new information may identify "extraordinary circumstances" relevant to an action that would necessitate preparation of an EA (or an EIS).]*

6) **Will the decision for the action be modified based on the new information and impact conclusions?**
   - NO – document determination not to revise the decision and go to 7.
   - YES – ensure that normal NEPA analysis and documentation requirements for making a new decision are met and go to 7.

7) **Is there new information relative to the ongoing action involving potentially affected federally listed or proposed species and/or ESA designated or proposed critical habitats?**
   - NO – no further action or analysis necessary; document findings.
   - YES – go to 8.

8) **Does the new information reveal effects to federally listed or proposed species and/or designated or proposed critical habitats in a manner or to an extent not previously considered? [e.g., the original consultation resulted in "no take" but the new information may result in "take."]**
   - NO – no further action or analysis necessary; document findings.
   - YES – New information may result in different conclusions of effects for species/critical habitat: (1) Additional adverse effects or different magnitudes of adverse effect (or effects to different life stages of the species) when the original effect determination was "Likely to Adversely Affect;" (2) Adverse effects where the original conclusion was "Not Likely to Adversely Affect;" or (3) "May Affect" when the original conclusion was "No Effect" or didn't include the species/critical habitat. Initiate or re-initiate formal consultation or initiate informal consultation, as appropriate, using the Streamlined Consultation process. Go to 9.

9) **For ongoing activities with initiation or re- initiation of consultation, is there a need to continue the activity during the consultation period?**
   - NO – suspend operation pending completion of consultation.
   - YES – go to 10.

10) **Would continuance of the ongoing activity cause irreversible or irretrievable commitments of resources which have the effect of foreclosing reasonable or prudent alternatives needed to avoid causing jeopardy or destroying or modifying critical habitat?**
   - NO – continue ongoing activity and document as "section 7(d) findings."
   - YES – suspend operation pending completion of consultation.